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A METHOD OF TESTING THE SUPERFICIAL BLOOD CIRCULATION FOR CONSIDERING THE INDICATION AND THE PROPER LEVEL OF AMPUTATION

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JUDGMENT as to whether an amputation is indicated in cases of disturbances of the blood supply is often very difficult. If the indication is clear, the choice of the site for the severing of the limb may offer still more delicate problems. The classic procedures of palpation of the arteries, the observation of the color of the skin, and the examination of the skin temperature by hand fail as a rule to give accurate information of the efficiency of the blood supply. The use of the blood pressure apparatus has been a step forward, and modern arteriography and oscillography have been fine contributions to the study of circulation. But arteriography is a rather complicated intervention, and probably not without danger for diseased arteries. Arteriography, as well as oscillography, only gives us an account of the capacity of the larger arteries and not of the blood supply to the tissues. Finer collaterals, which, for instance, have developed as substitutes for closed main arteries, may escape discovery even by arteriography, which has been most successful from a technical point of view, and may give no response to the oscillometer and still be quite efficacious in retaining the vitality of the tissues.

Examination of the blood supply to the integuments has been enhanced by the instrumental methods of testing the skin temperature by the thermocouple (Brooks) or the usual thermometer under a cover of felt (Ipsen). But when directly applied, they only give account of the blood supply under the actually existing conditions and not of the powers of reserve to which the body has to resort in cases of larger claims on the blood supply, as, e.g., after surgical interventions.

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Thus it has been a quite appropriate suggestion to try to *produce a hyperemia* in the diseased limb or at least in its integuments, and to examine the amount of increased filling of the capillaries as a method of judging the vitality in the actual parts. By such a procedure it would also be possible to get an *accentuation of the limits between satisfactory and insufficient blood supply.*

Moszkowics proposed (1907)[1] to produce this hyperemia by strangling the limb for a few minutes with an elastic band. This leads to an increased filling of the capillaries (by a temporary paralysis of the vasoconstrictor nerves?) to such an extent as the arteries are capable of supplying them. In most common cases where this examination might be desired, viz., the cases of arteriosclerotic gangrene, the method, however, seems to involve a certain risk of the chalk-incrusted, frail walls of the arteries being injured by the compression and thus eventually causing a more extended occlusion of the vessels by thrombosis. That is exactly one reason why we do *not* use Esmarch's bandage for the amputation itself in such cases. Moszkowics later (1913)[2] expressed the opinion that strangling is often unnecessary and that the changes of color of the skin by elevating the limb or bringing it into a dependent posture suffice for the test: in the case of a disturbance of the arterial supply, the elevated limb may assume the pallor of a corpse, and the increasing rubor of the dependent limb may be delayed. It is, however, a fact that the changes of color due to this simple method are as a rule too slight to be of sufficient value for testing the amount of the blood supply. Even with the original Moszkowics method, the hyperemia is not always well pronounced, and its limits may be quite diffuse. This may be still more the case in producing the hyperemia by rubbing the skin, even if in so doing an irritating substance is used, for instance, ether-alcohol (Sandrock, 1913).[3]

Lewis' cutaneous histamine reaction (the hyperemic "flare" after intradermal injection of 0.1 c.c. of a solution of histamine acid phosphate) has been used for the same purpose by De Takats and Mackenzie.[5] I have no personal experience with this method, but I think, however, it may prove to be a good test.

As to the value of examinations of the superficial circulation for the decision of the proper level of an amputation, it must be remembered that a satisfactory response in the skin does not guarantee a sufficient blood supply to the deeper parts, especially to the bone. But as an orientation which, in most cases, corresponds rather well to the exact circulatory conditions also in the deeper tissues, the examination of the blood supply to the skin, however, is worth consideration. As has been said above, preference must thereby be given to methods which give us an account, not only of the actual circulatory conditions in the diseased limb, but also of its capability of responding to an increased demand for blood at the level in question.

During the past twenty years, I have employed a method for this kind of examination which in two ways seems to me to be superior to those mentioned above:

1. In producing an irritation of such an intensity that the effect on the capillaries and small arteries becomes very large, probably maximal, thus giving the largest possible degree of hyperemia which is feasible in the actual condition.

2. In using the degree of another inflammatory reaction, viz., exudation and its clinical effect, the edema, as a measure of the vital response of the tissues to irritation and the presence of the lesion.

The method is based on brief *freezing of the skin with the aid of carbon dioxide snow.*

Fluid carbon dioxide is sprinkled in a little bag of velvet or leather, where it gathers in the form of snow. The snow is shaken out in a

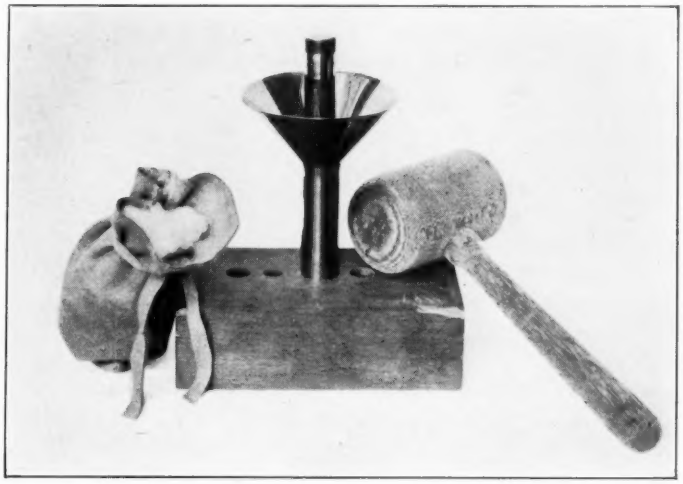

Fig. 1.—Bag with carbon dioxide snow, funnel, piston, and mallet for forming the ice-rod.

metal tube with a diameter of about 20 mm. and packed to a firm rod with the aid of a metal piston and a mallet (Fig. 1). The ice-rod is seized with a piece of gauze, its sharp edges are rounded off by sliding a piece of metal against them, and then the end of the rod is pressed against the skin for three seconds successively over the area to be tested in spots at a distance of 5 to 10 cm. from each other. The procedure begins at the most distal point to be tested and continues upward at a smart pace. For comparison the same procedure is repeated on the corresponding parts of the other limb.

In normal cases the white frozen spots of the skin thaw to normal consistency and color in *about one minute.* And then in another minute, the *hyperemia* sets in and soon becomes maximal.

The speed with which the hyperemia sets in and the grade of its intensity afford a certain guide as to the condition of the arterial supply

(Fig. 2). But a more accurate means of testing is possible when the maximum effect is reached. With the tip of the finger, we compress the hyperemic spot for 5 seconds, then hastily remove the finger and with a stop-watch *count the seconds which elapse until the spot has again reached its maximal filling with blood* (Fig. 3). Under normal condi-

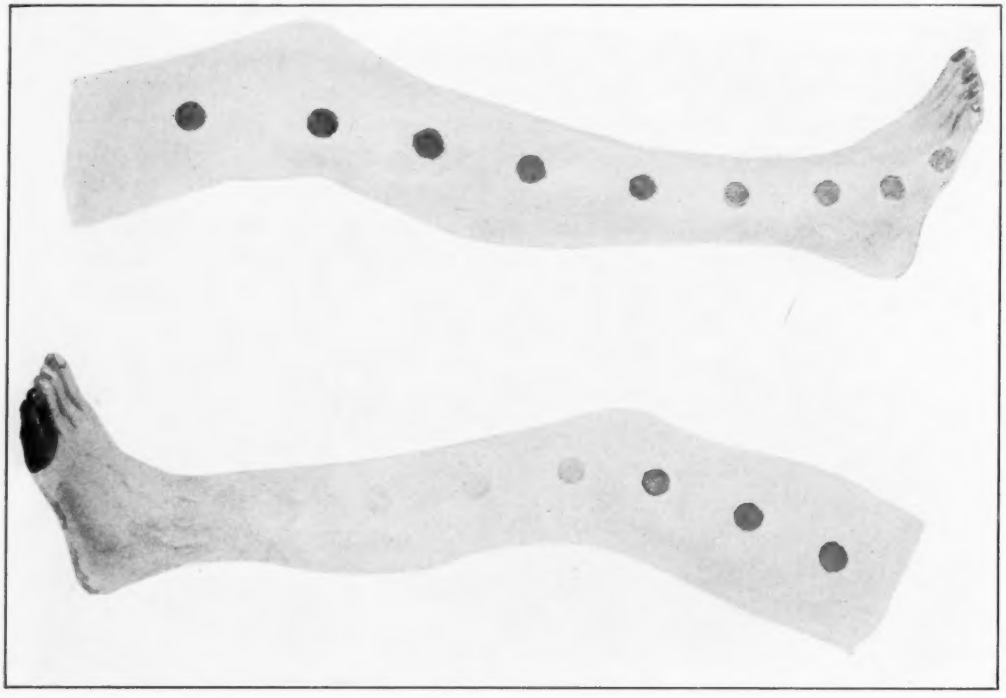

Fig. 2.—Spots of hyperemia about 3 minutes after the freezing in a case of arteriosclerotic gangrene of left foot. Upper figure, sound leg: maximal hyperemia in all spots but the lowest on the foot where its intensity is somewhat feebler. Lower figure, gangrenous leg: almost no response to the freezing on lower half of leg and on the foot.

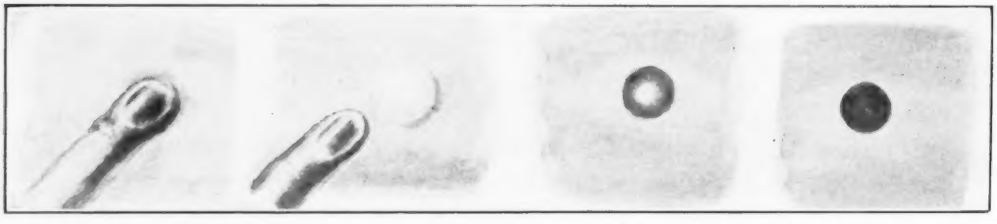

Fig. 3.—The refilling test. *1*, pressure with finger 5 seconds; *2*, finger removed: anemic spot; *3*, beginning refilling of blood; *4*, full hyperemia.

tions and in a horizontal posture, the refilling of blood takes an average time of from *1 to 2 seconds*. The return of the blood to the anemized spot is of a flaming character. With a bad arterial supply, the time may be extended to 10, 15, 20 seconds, or more. The intervals are noted with ink on the skin at the side of each spot and inserted in diagrams of corresponding sides of both extremities stamped on the history sheet.

When comparing the effect of the test on both extremities, it is essential to keep them in the same position, preferably the horizontal. In a dependent posture, the speed of refilling the anemized capillaries will increase manifold on account of the higher hydrostatic pressure and the stasis in the veins, which throw their blood back in the emptied capillaries. For instance, when the refilling in the horizontal posture takes a time of *4 seconds*, it may require only *1 second* when the extremity is dependent.

In normal conditions an *edema* begins to appear in the spot after 10 to 15 minutes and soon brings about a slight, sharply limited elevation of the skin. At the same time, the hyperemia vanishes under the increasing compression of the inflammatory exudate in the tissues, and the

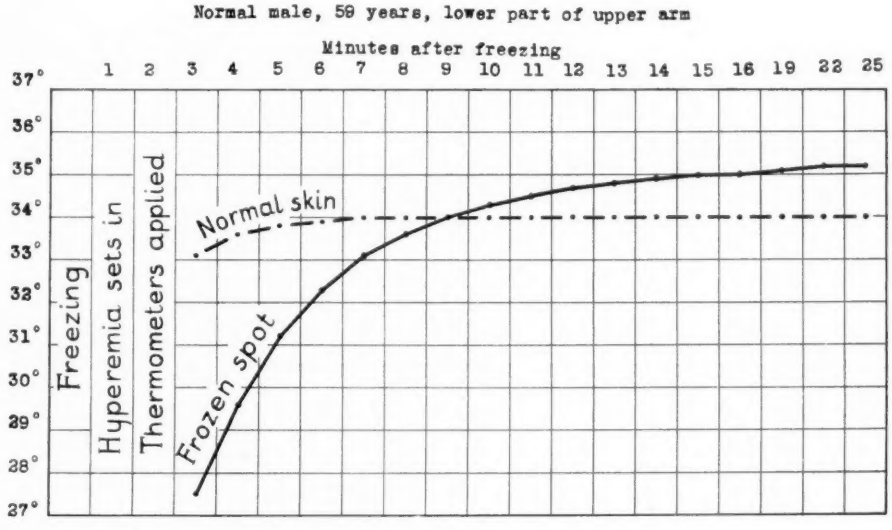

Fig. 4.—Temperature of the frozen spot.

swollen spots of the skin become more or less pale in contrast to a diffuse corona of hyperemia in the surrounding parts (Fig. 5). By and by the edema disappears, eventually leaving a little blister on the surface of the skin. The hyperemia returns, but some hours later the red color cannot be pressed away; the blood is now partly extravasated. The spot assumes a more cyanotic color which fades away in a few days, succeeded gradually by a faint pigmentation. The epidermis shows the usual thickening and exfoliation of its superficial layers as sequels of the slight "burn."

The freezing itself gives almost no discomfort and affords no subsequent inconvenience to the patient.

The temperature of the frozen spot has been examined with the aid of a usual maximum skin thermometer applied on a single frozen spot

with a diameter of about twenty millimeters under a cover of felt (Ipsen's method) and another thermometer applied in the same way on a control spot of the skin at the same level of the extremity.

During an interval of several minutes after the setting in of the hyperemia, the temperature of the frozen spot is lower than the temperature of the control spot. Under normal conditions (observations on two males of twenty-two and fifty-nine years of age, respectively) it does not reach the degree of temperature of the surrounding skin until about 8 to 9 minutes after the freezing, but then it continues to rise and reaches a maximum of 0. 8-1. 2 degrees Celsius or above the normal skin temperature at the same level of the extremity (Fig. 4).

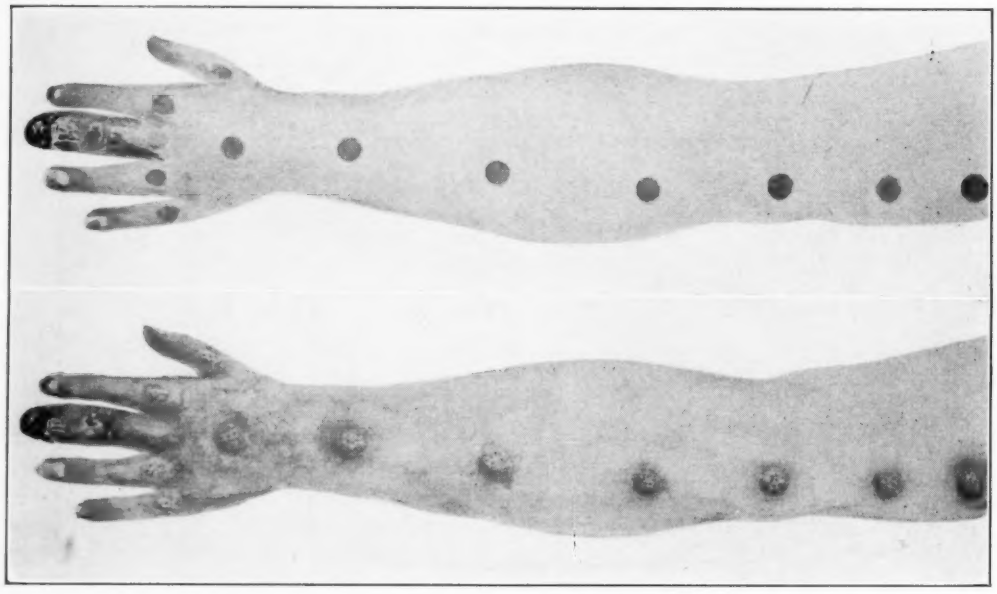

Fig. 5.—Freezing response in a case of Buerger's disease with gangrene of top of long finger: normal in all spots but at the base of the long finger, where both hyperemia and wheal formation are definitely reduced and delayed. Top figure shows hyperemia; lower figure, wheal formation.

This observation of hyperemia existing as long as 7 to 8 minutes before the temperature of the hyperemic spot has reached the normal level may possibly denote that the hyperemia at first is brought on by a dilatation of the capillaries alone, and that dilatation of the small arteries, which occurrence indicates a more active inflammatory reaction, sets in only after a certain time of "stupor," or perhaps of contraction of the arteries caused by the vigorous thermic injury. This suggestion is supported by the fact that edema begins to occur at about the same time as the temperature rises above the normal level.

As to the practical application of the results of the examination, I first tried to make the amputations immediately above the lowest spot which showed a good hyperemia and wheal formation, but in later

applications I have found it safer to choose a somewhat higher level, 10 to 15 cm. above the lowest spot with good response of hyperemia and edema.

CASE REPORTS

The following short records and pictures give an idea of the method which makes further descriptions unnecessary:

CASE 1.—Man, aged thirty-five years. *Thromboangiitis obliterans (Buerger's disease)* of arms and legs. *Top of left long finger gangrenous.*

Oscillometric examination: oscillations on both arms definitely less than normal; on left arm less than on right.

Freezing response: normal with exception of base of long finger of left hand, where a faint hyperemia appeared later; the refilling of blood after anemization was delayed; and the wheal formation of the frozen area was delayed and reduced (Fig. 5).

CASE 2.—Man, aged fifty-five years. *Thrombosis of bifurcation of aorta with embolus of right femoral artery. Freezing response:* left leg normal, right leg no response below middle third of thigh during first 5 to 10 minutes, then hyperemia also in a spot on lower part of thigh (Fig. 6).

CASE 3.—Man, aged seventy-seven years. *Arteriosclerotic gangrene.* Since youth, following trauma, recurrent ulcer on left leg. Otherwise in good health. Last 2 years increasing circulatory disturbances of left leg. Gangrene of left foot and lower part of leg now set in. General condition, bad. No glycosuria.

Freezing test: after 3 minutes, hyperemia only in the spots above knee with decreasing intensity downward. Later on slight hyperemia also below the knee, less pronounced the more distal the level; only surmised in the vicinity of the gangrene (Fig. 7). Wheal formation only in the spots above the knee. Refilling of blood after anemization of the spots occurs with decreasing rapidity downward.

Amputation above the lowest spot showing wheal formation. Died ten days later of increasing weakness.

Postmortem: stump without necrosis of the skin. Wound partly open at the surface, necrosis of musculature and fasciae of the size of an almond in vicinity of ligature of femoral artery. In this vessel, there was a newly formed thrombus proceeding upward in the external iliac artery; nowhere did it seem to be of earlier date, and only adhered loosely to the wall of the vessel. The lumen of the artery was wider previous to the thrombus formation.

CASE 4.—Woman, aged eighty-one years. *Arteriosclerotic gangrene.* Fifth toe, almost whole of fourth, and lateral part of third toe of right foot mummified. Some superficial ulcers on dorsum of foot. Cyanotic discoloration and edema of whole dorsum and distal parts of sole of foot. Cyanotic discoloration of heel soon after admission. Rigid arteries on both sides. No varicose veins. No glycosuria.

Freezing response: normal on thigh and leg down to about a hand's breadth above ankle joint; the next spot beneath this level only faint red; on the foot only slight touch of hyperemia.

During the following months, gangrene proceeded to second toe and lateral part of great toe. Four lateral toes then detached under good demarcation. Wound shrinking with slack granulations. Great necrotic spot on heel, with good demarcation, surroundings cyanotic. Nowhere was pulse felt in popliteal artery or arteria dorsalis pedis.

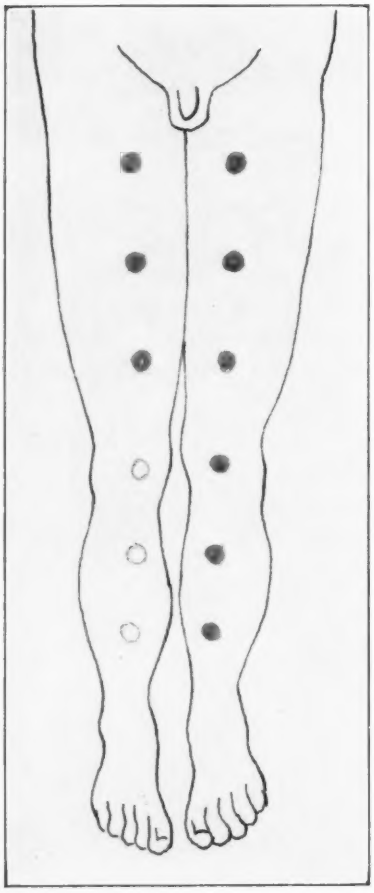

Fig. 6.—Freezing response in a case of embolism of the right femoral artery; no reaction below the knee.

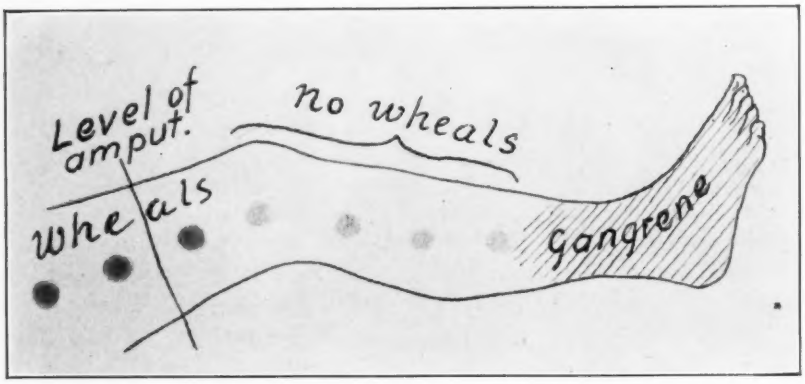

Fig. 7.—Freezing response in a case of arteriosclerotic gangrene.

New freezing test in order to determine level of amputation (Fig. 8).

Sound leg: hyperemia in all spots, even on the foot, wheal formation in all spots, with exception of one spot on the foot (?).

Bad leg: hyperemia as on first examination two months previously, thus faint on foot and lower half of leg, normal above middle of leg. Wheals faint or absent below middle of leg; *quite unexpectedly a rather definite wheal, however, appears on lateral part of foot quite near border of the toe-defect.* Thus: superficial circulation above middle of leg rather good and not impaired during last two months in spite

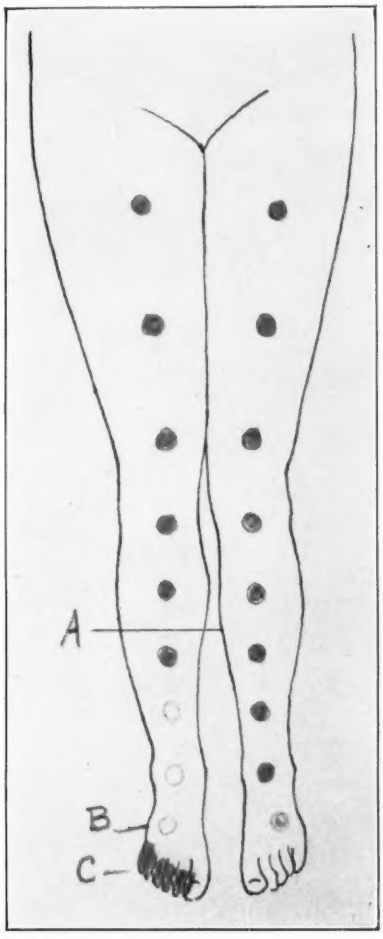

Fig. 8.—Freezing response in a case of arteriosclerotic gangrene: no hyperemia below middle of leg, but definite wheal in a spot on lateral part of foot. *A*, level of amputation; *B*, definite wheal; *C*, gangrene.

of proceeding toe gangrene; at the time below middle of leg bad, but irregular; the wheal formation in a frozen spot on the top of the foot denotes a restoration of circulation.

Amputation at middle of leg above the lowest spot with well-marked hyperemia and wheal formation. Weak pulsatile bleeding from both the tibial arteries. A narrowing of the anterior tibial artery by sclerosis was found immediately below the place where the vessel was severed. Both the tibial arteries could be injected rather well with minium emulsion, the posterior vessel with better results than the other. Vessels of the skin were thereby injected all over, though sparsely.

The *wound* seemed to heal perfectly. Following a postoperative rise, the temperature was normal on the fourth to the sixth day, but then rose again. On the ninth day, the edge of the wound was somewhat red and moist to some extent. It was opened here, and about 2 cm. beneath this part of the wound a small cavity filled with grayish pus and some necrotic shreds was found.

The patient *died* from bronchitis two days later.

Postmortem: femoral artery shows a free lumen; wall of vessel without note. Lumen of popliteal artery free until last 2 cm. where a small thrombus is attached to the wall, yet only slightly narrowing the lumen. In the anterior and posterior

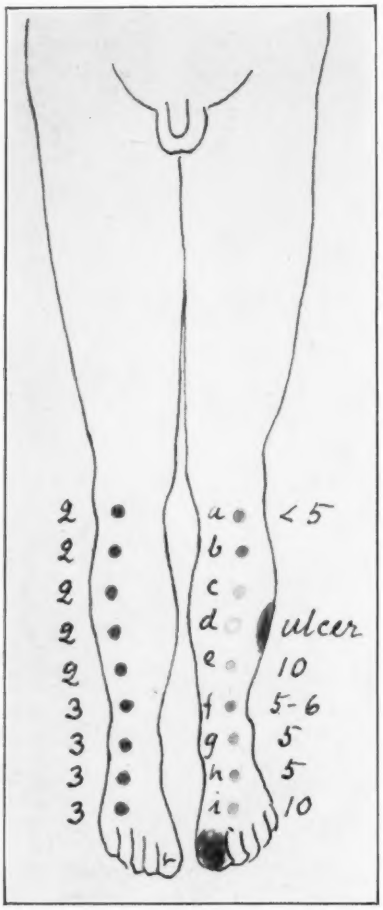

Fig. 9.—Freezing response in a case of arteriosclerotic gangrene. Sound leg: after 10 minutes, definite wheals in all spots. Bad leg: hyperemia delayed and reduced; almost no hyperemia in area surrounding ulcer; after 10 minutes no wheals. after 20 minutes definite wheals in spots *a* and *b;* faint edema in spots *e* and *g;* no edema in spots *c, d, f, h,* and *i.* Numerals at side of each leg indicate time in seconds for refilling of blood. Gangrene of left great toe.

tibial arteries, no thrombus and no narrowing of the lumen. *No necrosis of musculature or skin with exception of the above mentioned.* Definite arteriosclerosis of aorta and coronary vessels, fat infiltration of myocardium. Free excavated old thrombus in left ventricle.

CASE 5.—Man, aged seventy-five years. *Gangrene of great toe and ulcer of leg.* Rather acute circulatory disturbances of left leg, pains in great toe; a few days later gangrene of toe set in. A week later pulsations of popliteal artery disappeared;

Fig. 10.—Same case as in Fig. 9. Photograph of hyperemic spots. Note no hyperemia in the vicinity of the ulcer. Top figure, bad leg: gangrene of great toe; no hyperemia between *e* and *c*. Lower figure, sound leg.

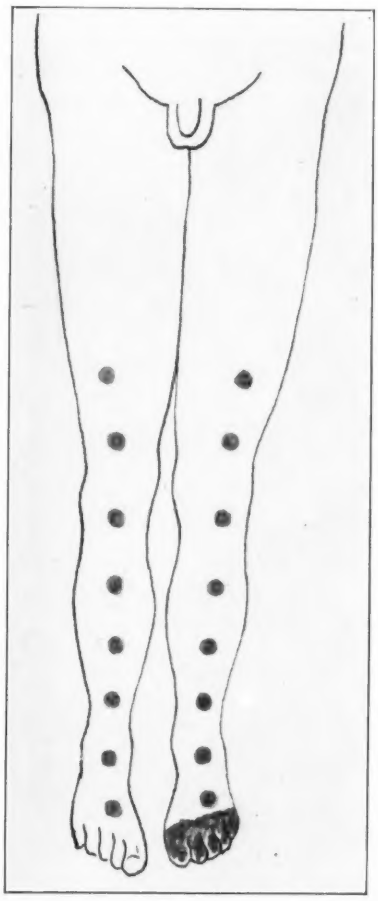

Fig. 11.—Freezing response in a case of diabetic gangrene. Note definite hyperemia in all spots right down to the edge of the gangrene.

ulcer developed on outer side of leg. Frightful pains in leg and foot. Impaired sensibility of foot. No varicose veins. No glycosuria.

Freezing test (see Figs. 9 and 10).

The following week a definite improvement. Gangrene does not proceed. Remaining hyperemia in spots of left leg and foot still obviously feebler than that corresponding on sound side. Refilling of blood on sound leg now in 1 to 2 seconds, of "flaming" character, on bad leg at the knee in 3 seconds, near ulcer in 6, and on foot in 8 seconds.

CASE 6.—Man, aged eighty-two years. *Diabetic gangrene at the top of left foot.*

Amputation of right great toe two years ago, then amputation of right thigh for rapidly spreading gangrene. Well healed. For one year, ulcers have been present on the left great toe; now gangrene at the top of foot; other parts of foot cyanotic, swollen. Pulsations in arteria dorsalis pedis. Upper parts of foot warm. Peripheral arteries rigid and very tortuous. Glycosuria.

Freezing test (Fig. 11): hyperemia in all spots until quite near the well-defined demarcation edge of gangrene. Refilling of blood after 5 seconds of anemization, complete in 2 to 3 seconds in all spots. Wheal formation, however, only in the uppermost two spots. Died a few days after the examination.

Postmortem: injection of arteries with minium emulsion. Femoral and popliteal arteries well filled. Posterior tibial artery closed by thrombosis to some extent in upper third of leg and in whole middle third of leg, below this part well filled. Dorsal artery of foot well filled. Large parts of anterior tibial artery obliterated; only disconnected parts of its middle extent have received injection substance. Numerous beautifully injected small vessels in skin, musculature, and fasciae right down to border of gangrene.

Thus both main arteries of leg obliterated to a great extent, but collaterals well developed.

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UNUNITED FRACTURE OF THE NECK OF THE FEMUR

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NONUNION in complete fracture through the central portion of the neck of the femur, or so-called intracapsular fracture, occurs more frequently than in any other bone. Not until the advent of the Whitman method of treatment was bony union of this fracture thought possible.

Sir Astley Cooper, and a majority of the older surgeons, believed that this fracture united only by fibrous tissue, and even since 1900, one will find statements to the effect that osseous union does not occur.

The abduction treatment of Royal Whitman is the greatest advance that has been made in the treatment of this fracture; it was first described in 1896. This procedure was soon accepted by a majority of the orthopedic surgeons as Whitman and others gave conclusive evidence of securing osseous union in many cases, and it was thought that failures were of rare occurrence. As the years elapsed, however, it was found that even with this procedure union could be secured only in approximately 53 per cent of the cases. This leaves a rather large number of individuals, 47 per cent, in whom union does not occur. In recent years, methods of internal fixation are largely supplanting this splendid procedure, and apparently the percentage of excellent results will be materially increased. However, even with any form of treatment, the physiology of the part is such that there will be many instances in which nonunion will occur. Also, a large proportion of fractures of the neck of the femur receive either inefficient treatment or no treatment at all, which results in nonunion.

The mechanics and physiology of this fracture are such that unless efficient treatment is administered, nonunion must invariably be expected. Since this fracture is of frequent occurrence, ununited fracture of the neck of the femur is common. The disability is great; in some with strong fibrous union, walking with a decided limp with more or less pain may be possible but the patient's endurance is very poor. In many cases, one or two crutches are required, and there is much pain and total disability. Much, of course, depends on the age and physical vigor of the individual, but, as is well known, the most frequent age of occurrence is above fifty years.

The important factors of anatomy and physiology of this region which are of practical value will be briefly discussed. In the normal

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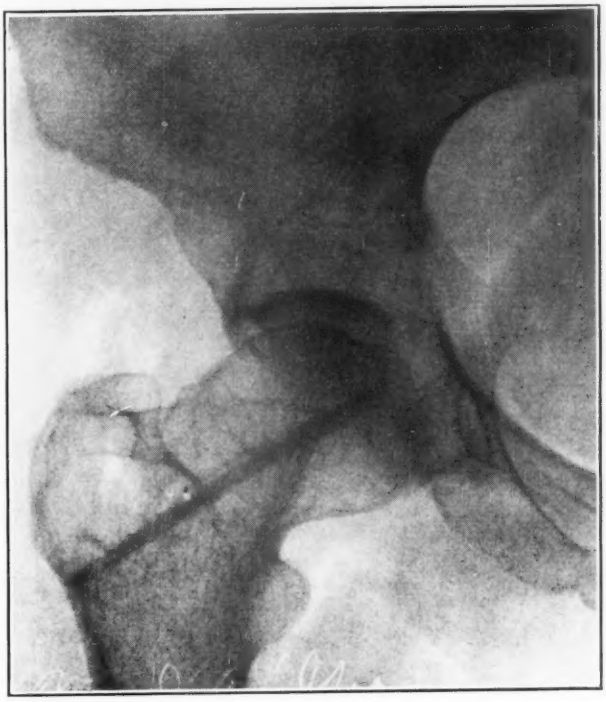
adult, the neck of the femur forms an angle of about 125° with the shaft. In the aged, this angle is often decreased and may at times be as low as 115°. The weight of the body transmitted through the neck to the shaft is thus placed on an oblique axis, which, like the axis of a wheel, is mechanically efficient until impaired. The neck is also deviated forward at the junction with the shaft, forming an angle in the anteroposterior plane of about 15°. The head of the femur and

A.

Fig. 1.—Age, forty-six years. (*A*) Bone graft neck of left femur for ununited fracture three years after operation, showing practically normal contour of head and neck. (*B*) Same case thirteen years following bone graft. Note pressure trabeculations along line of weight-bearing.

the acetabulum are thus on a plane anterior to the shaft and to the trochanter. Consequently, if a bullet enters the femur perpendicularly to the center of the greater trochanter, it would pass below and posterior to the head of the femur; but if deflected upward at an angle of 125° and forward 15°, it would pass through the center of the femoral head.

If the greater and lesser trochanters are removed, the femur forms a tubular, curved lever; according to Meyer and Cullman, the trabeculae of bone are arranged in the same manner as the trajectories of stress of a crane, being produced along the lines of tension and pressure. The pressure trajectories pass from the inner aspect of the shaft parallel with the inferior border of the neck into the head; the trabeculae of tension pass from the external portion of the shaft parallel with the superior border. These cross each other at an acute angle of about 45° just distal to the head. Wolff applied this principle to other bones and organs of the body and developed his famous



B.

law of functional adaptation. Murk Jansen, of Holland, disputed this theory, pointing out that such lines are not analogous to the trajectories of a crane, since the trabeculae in the neck of the femur cross each other at an acute angle, whereas the trajectories of the crane cross each other at a right angle. Jansen believes that these lines are due entirely to forces of pressure and that tension has no material influence. Roux has demonstrated that tension inhibits osteogenesis. Irrespective of that, whether caused by pressure and tension, or by pressure alone, this arrangement of the trabeculae is constant and has a practical application to the subject. As these lines cross in the neck of the femur, a triangle is formed in which there is less bone than in

other portions of the neck, producing a weak area which was described by Ward in 1838, and is known as Ward's triangle, through which a fracture of the neck of the femur usually occurs.

The hip joint is supported by powerful ligaments and muscles. The articular capsule is attached medially about the rim of the acetabulum slightly nearer the rim below and posteriorly, than it is above and anteriorly. At the femur, the capsule is fixed anteriorly to the anterior portion of the greater trochanter, along the anterior intertrochanteric line, inferiorly on a level with the lesser trochanter, and posteriorly

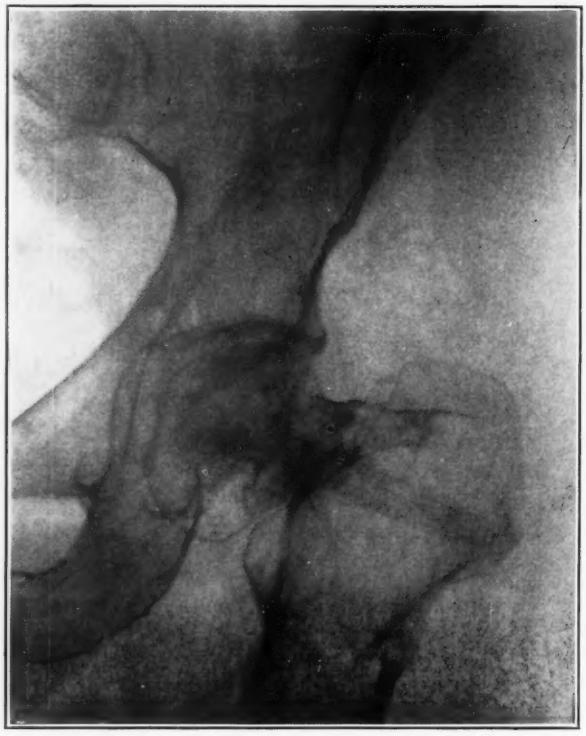


Fig. 2.—Age, forty-eight years. Bone graft operation following ununited fracture of neck of femur with marked absorption of neck. Solid union four months after operation. Osteotomy changed thrust of hip slightly.

along the base of the neck of the femur above the posterior intertrochanteric line, but leaving an extracapsular space of about three-fourths of an inch. The thickness and strength of the capsule varies in different regions, as there are three sets of auxiliary fibers, only two of which are of sufficient importance to be considered, i.e., the iliofemoral and the ischiofemoral ligaments. The iliofemoral, or Y-ligament of Biglow, is the strongest ligament in the body; it is attached above to the ilium immediately below and behind the anterior inferior spine, and is inserted into the greater trochanter and into the anterior intertrochanteric and spiral lines as far as the medial border of the

shaft of the femur. The ischiofemoral band arises from the ischium between the lesser sciatic notch and the obturator foramen and is inserted into the greater trochanter in front of the insertions of the pyriformis tendon and into the superior and posterior parts of the neck of the femur. The anatomy of the muscles of this region is well known, and requires no description except to mention the powerful external rotators which play a definite rôle in this fracture. The gemelli and obturator internus are said to rotate the head of the femur

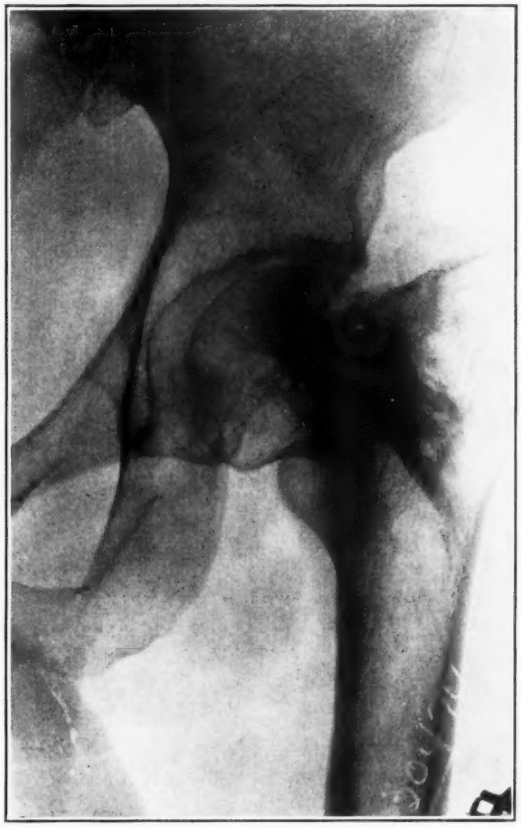


Fig. 3.—Age, fifty-one years. Bone graft after considerable absorption of neck. Almost normal function.

backward after fracture. The iliopsoas and pyriformis pass over the neck of the femur, and it has been suggested that they become caught between the fragments in femoral neck fractures, although the probability of this is doubtful.

As an adequate blood supply is the most important factor in the production of callus, a thorough knowledge of the circulation is necessary for an understanding of the process of healing. Wolcott has recently demonstrated an anastomosis between the arteries of the ligamentum teres, the head, and the posterior capsule. When a

femoral neck fracture occurs, the outer fragment of the shaft of the femur is rotated outward and displaced upward. Outward rotation is produced by three forces; first, by the reflex contracture of the powerful abductor and external rotator muscles; second, by the ischiofemoral ligament which is made tense as the fragments separate; and third, by the force of gravity which is influenced by the angle of attachment of the foot to the leg. The outer fragment is thus on a plane above and facing directly forward, being completely separated from the proximal fragment or head, which is usually rotated backward by the obturator internus and gemelli.

Fig. 4.—Age, fifty-nine years. Bone graft maintaining position of extreme coxa valga after complete absorption of neck. Resultant change of weight-bearing. Excellent function. Same principle as osteotomy. This procedure in 1929.

The theories of the more frequent occurrence of nonunion in this region may be considered as follows:

1. Deficient circulation due to severance by the fracture of the main blood supply to the head of the femur which must depend upon vessels in the ligamentum teres and which may be more or less decreased in lumen as age advances.

2. The circulation is regarded by some authors as sufficient to secure union in those cases accurately reduced but admit that the shearing

action may impair circulation and callus formation. Stress of this nature would be eliminated by internal fixation, or osteotomy, as described below.

3. Osteoporosis or bone atrophy with more or less fatty substitution and increase in size of Ward's triangle as above described.

4. Inefficient reduction, fixation, and after-treatment.

5. Weight of the body is transmitted on a more or less transverse plane through the site of fracture.

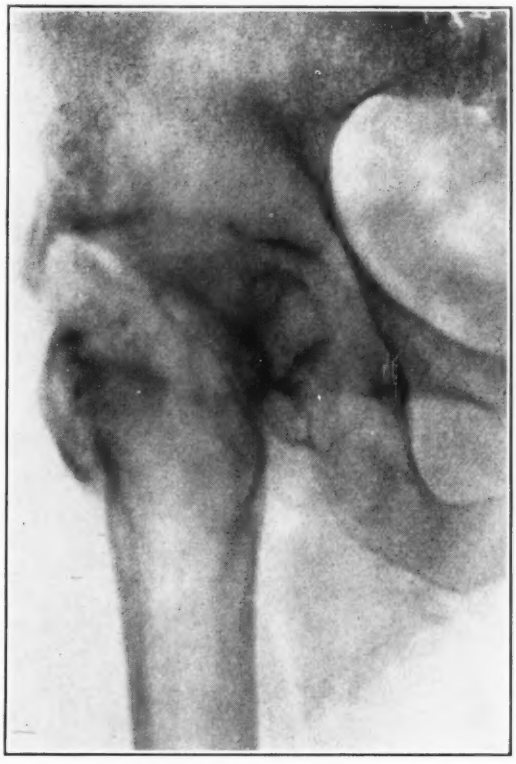


Fig. 5.—Age, fifty-seven years. Combined Brackett and shelf operation with excellent functional result.

6. Any movement causes a shearing action at the point of fracture which is always conducive to the organization of bone on the surface of the fragments and not across the line of fracture.

7. The normal process of union is impaired, as callus is derived chiefly from the distal fragment. All callus is intermediary, there being no reaction on the part of the periosteum, since the cambium layer of the periosteum on the femoral neck is said to be absent.

8. Union is always delayed when compared to other fractures, and a permanent status of nonunion occurs in those not reduced in approximately thirty days.

9. Functional use before nature has had sufficient time to firmly consolidate new bone, impairs, or it may even cause disintegration of the reparative process.

10. The synovial fluid may possibly have a deleterious action upon callus production.

11. The head is a terminal fragment; somewhat similiarly, union often fails elsewhere in the body regardless of age, as in fracture of the external condyle of the humerus and the carpal scaphoid.

12. The blood clot which is essential to early bone regeneration is said to be deficient in this fracture.

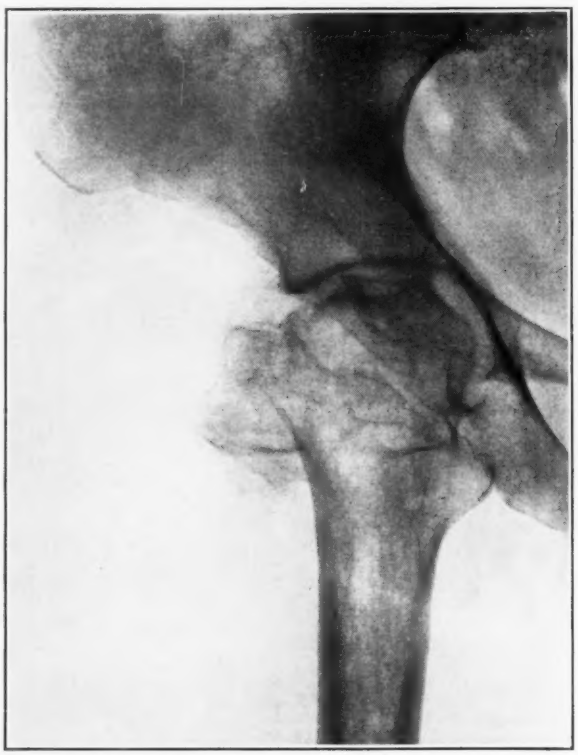


Fig. 6.—Age, forty-nine years. Whitman reconstruction operation. Excellent function.

13. The capsule may be torn and caught between the fragments; also, certain muscles could possibly be interposed.

The physiologic reparative process differs from that of other fractures to such a degree that it may be regarded as almost pathologic. This is chiefly in the behavior of the head or proximal fragment. In the opinion of Sir Astley Cooper, the head always becomes necrotic and does not unite by bone. Axhausen and Bonn at the present time also state that the head becomes necrotic. Santos, however, has made an exhaustive investigation as to the reaction of the head which explains more clearly the pathology. We have also examined a number

of specimens in our laboratory and have corroborated Santos' conclusions. These changes deduced from the investigation of Santos may be enumerated as follows: the head may remain alive, as indicated by roentgenologic examination which demonstrates that the bony structure may become atrophic to the same degree as the surrounding bone in the ilium and the trochanters; or the head may die and become a sequestrum, as demonstrated by the bone retaining the same density

Fig. 7.—Age, fifty-eight years. Whitman reconstruction operation with almost normal function.

as at the time of the fracture, the sequestrated head, therefore, remains opaque or dense, standing out in marked contrast to the surrounding atrophic bone.

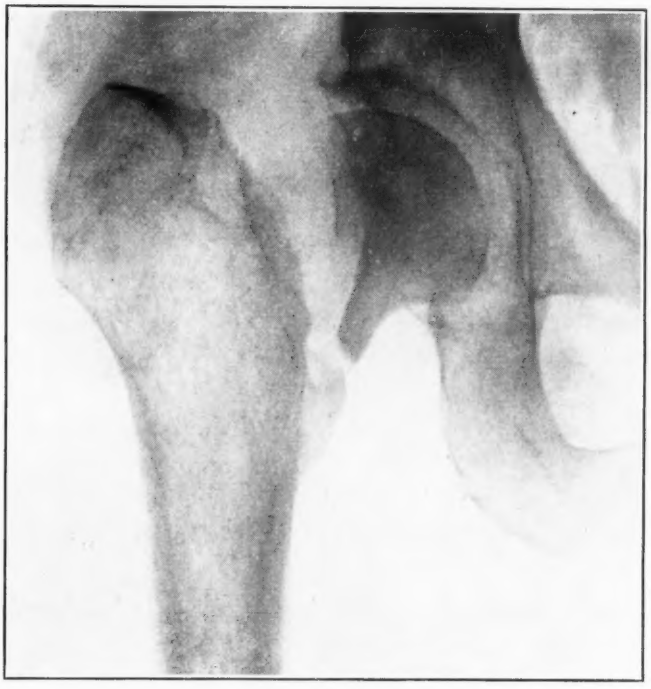
Microscopic examination of the living head demonstrates atrophic changes; the trabeculae become thinner, and the narrow spaces are increased in size and substituted by fat. The articular cartilage becomes thinner, and the subchondral marrow spaces may so enlarge that the encrusting cartilage sinks below the surface, thus causing an ir-

regularity in the contour of the head. Microscopic examination of the necrotic head demonstrates the usual characteristics of dead bone, in that the lacunae are empty and the staining quality of the few remaining cells is impaired. Fibrous tissue invades from the fovea, which is probably instigated by the vessels of the ligamentum teres. New bone is formed by this tissue, until the entire head or any portion thereof may be restored to living bone. The articular cartilage dies, undergoes fibrillation, is exfoliated and absorbed. Adhesions form between

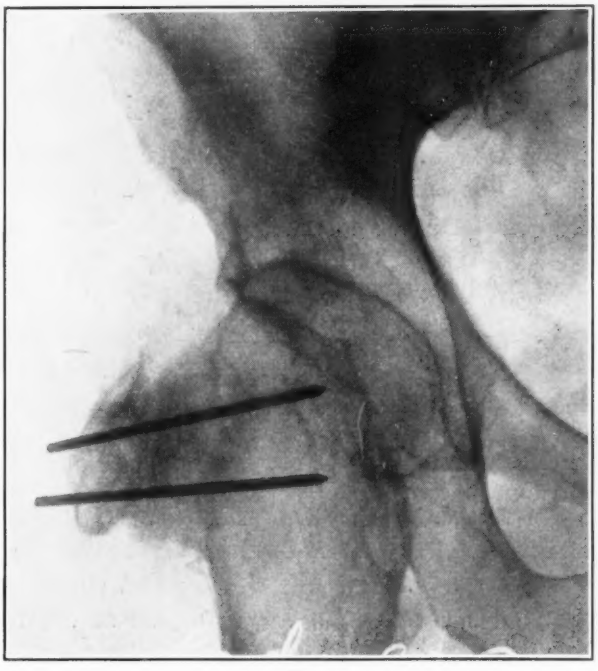
Fig. 8.—Age, sixty-two years. End-result of Whitman operation with dislocation. Marked atrophic changes with absorption.

the head and acetabulum, from which there may be further invasion of fibrous tissue which becomes converted into bone.

When the living head unites and function is increased, the structure of the bone is gradually restored to normal in the same manner as the surrounding osseous tissue. When the living head fails to unite, there is gradual atrophy until only a small portion may remain. When the dead head unites, the entire head may be gradually invaded from the fovea and from the distal fragment, or small sequestra may be extruded into the joint. Thus the globular contour of the head may become



A.



B.

Fig. 9.—Age, fifty-four years. (*A*) Ununited fracture of ten months' duration; wide separation of fragments. (*B*) Reconstruction operation which consisted of detaching trochanter and transplanting head as a graft to lateral aspect of femur, with restoration of normal fulcrum, and maintaining upper extremity of femur in acetabulum.

more or less incongruous. When the dead head does not unite, the size becomes diminished by a process of erosion and is usually invaded by new bone until the entire structure is restored, after which the density and appearance are the same as that of the living head and the surrounding living tissue.

Many operative measures have been employed for the relief of this deplorable condition. Before the mechanics were understood, excision of the head was employed with little if any improvement. But as soon as it was recognized that a firm bony support to the upper extremity of the femur was required, better results were attained. Operative measures for this purpose may be enumerated as follows:

1. Bone graft, or so-called "pegging" of the fragments with a large autogenous graft from the tibia.

2. Brackett operation which consists of scooping out the interior of the head of the femur, denuding the distal fragment, and placing it within the excavated head.

3. Albee operation which consists in excising the head and dividing the shaft of the femur longitudinally for several inches, and deflecting the external fragment outward and placing the upper end of the femur within the acetabulum. The head of the bone is placed between the fragments, thus maintaining the trochanter outward, which restores the leverage action of the muscles.

4. The Whitman operation which consists in detaching the greater trochanter with attached abductor muscles and removal of the head of the femur. The upper extremity of the femur is then placed within the acetabulum, and the trochanter is reattached on the external surface of the shaft of the femur several inches below the normal attachment, thus approximating the upper extremity of the shaft to the acetabulum and giving better leverage action to the abductor muscles.

5. Reconstruction operation which consists of detaching trochanter and transplanting remodeled head as a graft to the lateral aspect of the femur, and reattaching the trochanter to this graft by means of a wire nail, restoring the normal fulcrum and maintaining the femur in the acetabulum.

6. Osteotomy of the shaft of the femur at about the level of the lesser trochanter, after which the shaft is displaced inward beneath the head and fracture line. The superior osseous support is thus restored and at the same time the shearing action at the fracture line is eliminated.

7. Osteotomy of the shaft at the level of the tuberosity of the ischium with inward angulation of the fragments (Schantz). After union of the fragments, the femur and extremity is stabilized and supported by the lateral aspect of the pelvis; the shearing action is also eliminated.

A.

B.

Fig. 10.—Age, sixty-six years. (*A*) Nonunion fracture neck of femur after six months well-leg traction. (*B*) Six months later, solid union after subtrochanteric osteotomy.

The author and his colleagues have employed all of these procedures with the exception of the last. A review of our private records of seventy-five cases in which operation has been employed for central ununited fracture of the neck of the femur forms the basis of this discussion, the end-results of which may be enumerated by the following table:

The bone graft operation was employed in thirty-six cases, but it is only indicated in those in which the neck of the femur is well preserved, and in consequence is rarely advisable after the lapse of one year. The great disadvantage is the prolonged after-treatment which

A.

Fig. 11.—Age, sixty-one years. (*A*) Ununited fracture neck of femur, seventeen months' duration. (*B*) Smith-Petersen nail used; good approximation of fragments. Subtrochanteric osteotomy with beginning union. Patient walking in brace. Apparently good result.

is often required before the roentgenogram will demonstrate bone trabeculae traversing the line of fracture which is the only sign by which osseous union can be determined. This operation is the ideal procedure, as perfect anatomic restoration is possible, but as many elderly individuals cannot stand further prolonged confinement, the procedure is only advisable in selected cases.

I have employed the Brackett and Albee operations in too few cases to warrant an opinion, except to state that I have seen excellent results

with each procedure. The reconstruction was usually employed in those cases in which a long period of time had elapsed, in aged individuals, and in those with extreme absorption and separation of fragments. In approximately 60 per cent, the Whitman reconstruction operation will give excellent results and a fair chance of restoration, or at least a high per cent will be materially improved. Excellent results after this operation are relative, since the condition of the patient is by no means as good as in those cases in which the bone peg

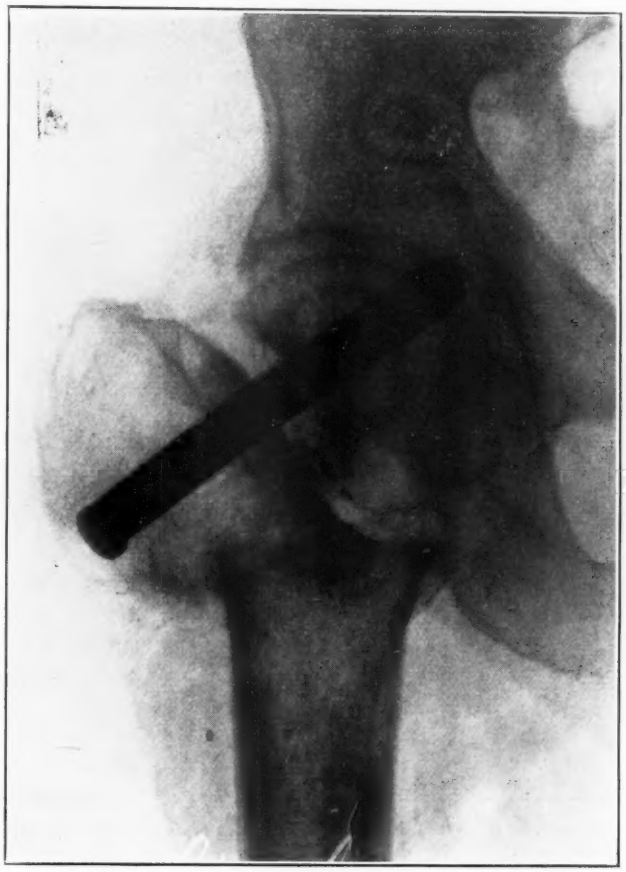


Fig. 11-*B*.—See opposite page for description.

operation succeeds. Two of the cases continued to use crutches but were relieved of pain and greatly improved; they probably could have walked without support if they had been less apprehensive and more cooperative. The remaining twelve were able to walk with definite limp and were materially improved, much depending on the muscular restoration in the individual case. In two of the Whitman operations, the upper extremity of the femur could not be maintained within the socket and dislocated or subluxated, giving an unstable hip which was

no improvement over the former state. This may have been due to the loss of proper leverage or to weak musculature. In a number of cases, a bony shelf was made from the ilium to deepen the socket and prevent this complication.

The author has employed a technic (No. 5) which consists of detachment of the trochanter, excision of the head, remodeling of the upper extremity of the shaft, and placement of it within the acetabulum. The head of the bone is then denuded of cartilage and made into a

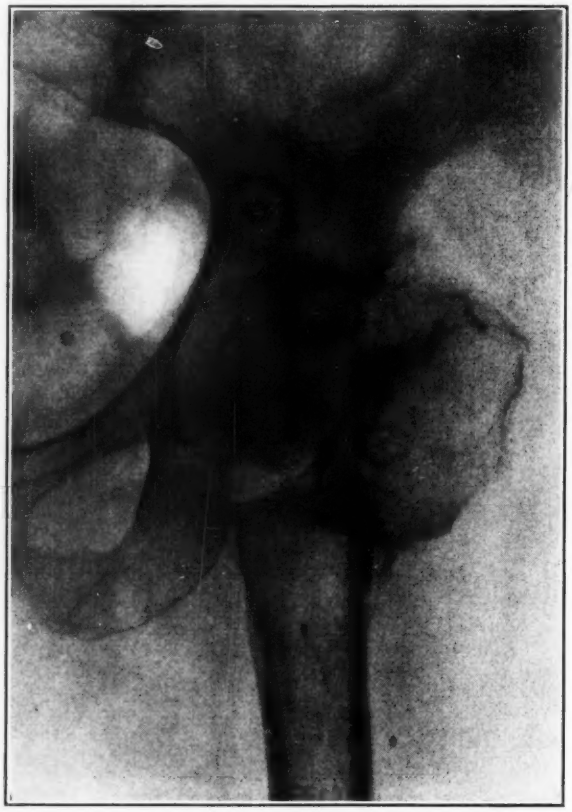


Fig. 12.—Age, seventy-one years. Subtrochanteric osteotomy four months after operation. Too early to determine union, but patient has excellent functional result.

cube which is employed as a graft. An area is next denuded on the external aspect of the shaft below the site of the greater trochanter to which the graft is approximated. The detached trochanter is next brought down and closely approximated to the graft. Two rustless steel nails are now inserted through trochanter, graft, and shaft. The trochanter is thus attached at a lower level, and the transposed head displaces the trochanter outward, thus giving more efficient leverage and holding the upper extremity of the femur within the acetabulum. In other words, a new neck is substituted, giving a more normal me-

chanical status. The procedure combines the principles of Albee and Whitman. In only one case can the result be estimated, and that was excellent.

The osteotomies and plastic procedures are too recent to draw definite conclusions. It is most interesting, however, to note that apparently excellent functional results have been secured in all of these cases by simply eliminating the shearing action at the point of fracture. In one case treated elsewhere by continuous well-leg traction for six months without union, in a debilitated woman sixty-six years of age, osseous union was induced in six months, and the patient has a most excellent result. In three cases, there was extensive absorption of the neck with such a wide separation between the head and neck that a closer approximation was made between the fragments by internal

TABLE I

BONE PEGGING	
Solid bony union	20
Failure	8
Unknown or too early	7
Died	1
Total	36
RECONSTRUCTION	
Excellent	14
Failure	8
Unknown	12
Died	1
Total	35
OSTEOTOMIES	
Excellent	1
Too early	3
Total	4

fixation before osteotomy, as above described, was employed, thus possibly enhancing union between the fragments, or at least producing more stability. In one instance, a Smith-Petersen nail was employed for this purpose, and in two cases, bone grafts. In two, the results are excellent, and one is too recent. At the recent Congress of the Internationale Orthopedic Association in Rome, Dr. Faldini, of Milan, demonstrated about twenty cases in which he had employed the low osteotomy in fresh fractures of the neck of the femur, thus supporting the limb by the lateral aspect of the pelvis. The results were excellent and amazing, the patients walking with scarcely a limp.

This type of operation (Nos. 6 and 7) surely adds a new principle and procedure to our armamentarium. The surgical risk is much less and can certainly be employed under less favorable physical condition

than the other more formidable measures, and it is quite possible may, to a large degree, supplant other surgical procedures, not alone in nonunion but also to some extent in fresh fractures.

The average decrease in the length of the extremity in the bone graft operation varied from one-fourth to one and one-fourth inches, and in the reconstruction operation from one-half to two inches; however, this is not an element if better function can be secured. By these measures above described, there is reasonable chance of securing a high percentage of function in those in whom no improvement could be expected.

The most important factor that I desire to emphasize is the early recognition of nonunion in this fracture which is present in all cases not reduced under thirty days and in those in which there are late changes in the relation of the fragments. Better results with more muscle power are secured in those which can be operated on before there is extensive osseous atrophy.

In the above survey, many months and often years had elapsed in a majority of the cases before aid was sought. Undoubtedly a much higher percentage of excellent results could have been secured if efficient measures had been instituted earlier.

DISRUPTION OF ABDOMINAL WOUNDS: AN UNSOLVED PROBLEM

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WITHIN the last six months, two patients, on whom I had performed laparotomy through a right rectus approach, suffered disruption of the incision. In neither case was there any evidence of infection of the peritoneal cavity, or of the incision. In one instance, the patient was fat and with a moderate jaundice at operation. She was fifty-eight years old, and cholecystectomy had been done. On the fifth day, there was considerable discharge of bloody serum in the dressings, and, when the wound was examined, there was complete separation of all the layers of the incision, but without any protrusion of abdominal contents. Careful examination of the wound edges from skin to peritoneum failed to discover any catgut, except two knots lying free, and these were in the late stages of disintegration.

The second patient was fifty-one years old, moderately fat, but without jaundice; cholecystectomy had been done. On the seventh postoperative day, there was an abundant discharge of bloody serum in the dressings, but the skin incision was intact, and it was thought that the anterior layer of the rectus sheath was not separated. He had no fever or unusual abdominal discomfort. His abdomen was not distended, he had not been vomiting and was apparently making an uneventful recovery. His abdomen was snugly strapped with adhesive tape, and his convalescence was otherwise a smooth one. Within a few weeks, however, following the upright position, he developed a large hernia, occupying the entire length of the incision.

In each of these patients, the wound was closed with continuous No. 2 chromic gut in the peritoneum and posterior sheath of the rectus, and interrupted No. 2 chromic gut in the anterior sheath, interrupted 00 plain gut to approximate the fat, and fine black silk in the skin.

Hinton suggests that allergy may be the "explanation of wound dehiscence and incisional hernia," and he used solutions of fresh sheep-gut in intradermal injections on 112 patients. Nine of these patients showed a moderate local reaction.

Babcock reported a number of experiments in which the local reaction of human tissues to different suture materials was observed and stated

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that both plain and chromic catgut gave a uniform, but varying local reaction, when imbedded in the skin. He called attention to the disappearance of catgut in disrupted wounds.

Disruption of the abdominal incision is a serious postoperative mishap. In 1933, a symposium was held on this subject by the New York Surgical Society; as a result of that discussion, a number of excellent papers are in the literature. The following statement is from Hinton's recent paper:

"Papers were read by members of the staffs of five hospitals in New York, and Meleney and Howes reported 55 cases from the Presbyterian Hospital in an eight-year period, or an incidence of 1 per cent. They thought that the diagnosis had been frequently omitted from the records if there had not been a secondary closure and that 2 per cent would more nearly represent the incidence of this 'catastrophe.' Colp reported 29 cases in 2,750 laparotomies, or an incidence of 0.9 per cent, from the Mount Sinai Hospital. Grace reported 44 cases in a fifteen-year period from the first surgical division of the Bellevue Hospital. White reported 30 cases from the Roosevelt Hospital. Heyd reported 4 cases in 1,000 laparotomies performed at the New York Post-Graduate Hospital in 1932 and 4 personal cases. There was a total of 166 cases reported at the meeting of the New York Surgical Society. Sokolov in 1931 reported the largest group of cases on record, numbering 725, based on the experience of 187 surgeons. He sent questionnaires to 1,140 European surgeons. Eliason and McLaughlin reviewed 9,155 operations at the University of Pennsylvania Hospital and found 25 instances of dehiscence. Maes, Boyce and McFetridge reported 44 cases in a ten-year period at the Charity Hospital in New Orleans. Baldwin reviewed his individual series and found that in the past thirty-five years he had not had a single instance of dehiscence in 16,465 operations. After one studies these reports as to the cause, prevention and treatment of this serious sequela of celiotomy, it is difficult to evaluate the opinions expressed by the different authors."

When I first began operating, I followed the practice of most Baltimore surgeons of that period and closed the abdomen with fine silk from peritoneum to skin, using, in the main, interrupted sutures. This method has a number of objections. It is slow and tedious, and fine silk is relatively difficult to handle. It breaks easily if too much tension is put on it, especially if the second knot is snapped down too sharply. The greatest objection to it comes from its behavior in infected wounds. Then, there is the prejudice against leaving foreign material in the tissues. Another objection to silk has to do with the preoperative technic. If silk is wrapped tightly on the spool, routine boiling will not completely sterilize it, and a low grade localized infection may develop some weeks subsequent to operation. The first and last objections may be overcome by proper care. Because of the above factors, and in con-

sequence of the great improvement in the manufacture of catgut, I followed the general trend and began the use of gut. I often made the mistake of using larger catgut than was necessary and did not realize that a suture need not have any greater tensile strength than the structures that it approximates, provided the suture continues to function until union is secure.

During my service in a base hospital in this country in 1917, I did a great many hernioplasties using chromic catgut. These patients were all young. Most of them were thin and in excellent physical condition and were, of course, fine operative risks. We did not have any means of following them up; the operative results seemed satisfactory. Following the war, for a period of about two years, I used catgut in all hernioplasties and soon began to notice an increased percentage of recurrence; since 1922, I have used silk, linen, or fascia. About this time I began to close the abdomen, except the McBurney approach, by a combined method, safeguarding the use of catgut by interrupted sutures of heavy, soft white silk including all layers of the abdomen, except the peritoneum. This is a satisfactory method in my experience, except in fat persons in whom the interrupted silk sutures have a tendency to cut through if tied snugly and are apparently of little benefit if tied loosely.

Since the two mishaps mentioned in the beginning of this paper, I have closed the peritoneum with fine, chromic gut, and the remainder of the incision with fine silk. I am writing this personal experience of vacillation and anxiety, because it is a fairly accurate picture of what has been occurring in the minds and experience of many surgeons.

There is abundant evidence in the literature that behavior of abdominal incisions has been the cause of much uncertainty and perturbation. The reports fall in two groups. In one, research and investigation have been carried on to determine just what happens in a wound undergoing repair, and to observe how these changes are modified by chemical and physical agents. Harvey and Carrel especially have been interested in this phase of the problem. In the other group are found many clinical reports of dehiscence of the sutured abdominal wall.

Two distinct conditions are found in incisions that fail to unite promptly. In infected wounds the etiology and pathology are understood. Serious infection of the abdominal incision will interfere with the normal processes of healing and may be followed early by rupture of the wound or later by herniation. The infection may be an extension from the abdomen, or a wound infection confined largely to the abdominal wall. Usually the former condition exists. In severe infections, it matters very little what method of closure is used, so far as the tendency to disruption is concerned. If gross rupture does not occur, a surprisingly good repair of the abdominal wall may be obtained, provided the patient escapes the risks of the infection.

There is another group, however, in which observation and investigation prove that wound infection does not play the major part, and other factors must be considered. But, in the meantime, hundreds of laparotomies are being performed daily, and the possibility of disruption of the wound creates a risk to the patient and a state of anxiety in the mind of the surgeon.

Dehiscence of the incision is followed by a death rate that is very disturbing. It is often difficult to separate the two groups in estimating the mortality reported in the literature. Much of it is due to infection, and the underlying peritonitis is chiefly at fault. In this group the mortality is very high. In those patients where infection is not present, and where the condition is recognized promptly and reoperation immediately performed, the death rate is lower. In the *Annals of Surgery* for September, 1925, the writer reported five such secondary closures without mortality.

In the combined group, however, the mortality is appalling. "Meleney and Howes found a mortality of 44 per cent, Colp of 28 per cent, Grace of 39 per cent, and Sokolov of 33 per cent. The mortality in the cases reported in this paper was 16.7 per cent. When the three fatalities are reviewed (Cases 13, 17 and 18) it can be seen that the primary cause of death was diffuse peritonitis. The uncomplicated cases of dehiscence of the wound rarely cause death if one is constantly watching for the first signs of this tragedy" (Hinton). The next sentence in Dr. Hinton's paper immediately following the above quotation is very striking—"Dehiscence of the wound has caused me more consternation than any other sequela of abdominal operation."

Surgeons, therefore, are faced by a very real problem. What can be done to lessen the percentage of broken-down, uninfected abdominal incisions? There are many reports on the healing of wounds. Most surgeons believe that clean wounds heal without any local aid, that wounds heal best when least disturbed by trauma or chemicals, and that the suture material should possess adequacy with the minimum of bulk and irritation.

There are a number of anatomical considerations. The abdominal wall is attached to the costal margin, to the lumbar vertebrae, and to the pelvis. When the patient is lying in the recumbent position, the spine and pelvis are relatively fixed and still, but the costal margin is moving constantly, and with each inspiration, there is a lateral pull on the two sides of the abdomen tending to increase the tension on the suture line. The nearer the incision is to the rib margin, the greater the degree of pull. The blood and nerve supply are important factors also. Thin fascia and poorly developed muscle enter into the problem, and fat is a lubricant that interferes with healing, especially if it is allowed to thrust itself between the wound edges.

A very important thing is the transverse direction of the deeper layers of the abdominal wall giving poor support to the suture line of a vertical incision. Pool, in 1931, reported a method of closure with this fact in mind. One of the advantages of the transverse upper abdominal approach is a more secure suture line. Lynn and others have called attention to this.

There has been a widespread belief in a number of factors outside the wound itself that hasten or retard union. Among these are kinds of food, dehydration, infection in other parts of the body, especially in the chest, liver dysfunction, kidney damage, age, starvation, vitamins, endocrine activity, abdominal distention, vomiting, etc. Conflicting statements are made by different observers, and there is considerable confusion, but evidence seems to be accumulating that, in addition to the above-mentioned causes, there occurs in certain incisions an undetermined type of wound reaction in which the usual processes of healing are interfered with; and there is a distinct group in which infection, as we understand it, plays little or no part.

There are two conditions, however, about which there is no question as to their ill effects upon wounds—blood supply and diabetes. It is an axiom as old as modern surgery that diabetes should be brought under the best control possible and kept there during the period of wound healing, and that both the general and local circulation should be safeguarded.

There are four important steps in performing an abdominal operation. The first has to do with preparation of the patient, of the dressings, the instruments, the training of nurses and assistants, etc. The second is the operative approach. It is known, of course, that some incisions give less trouble than others. The third is the operation itself, which should be done gently, neatly, and thoroughly, having in mind immediate results, postoperative adhesions, and intestinal obstruction. These things are so well known that to repeat them is to be tiresome. The final step is the one about which there is lack of agreement, much anxiety, and no little grief—the method of closure. Many different materials are used. No single way of suturing the wound edges has been proved uniformly satisfactory. The problem calls urgently for solution.

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POSTOPERATIVE WOUND SEPARATION: REVIEW OF CASES

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THE discussion on postoperative wound rupture at a recent meeting of the New York Surgical Society has stimulated renewed interest in this condition as indicated by the number of subsequent papers. It is fully realized that inferences drawn from a small series such as this may be misleading, but at the same time it is hoped that the presentation of this review will be a contribution to the general statistical studies on the subject.

Postoperative wound rupture occurred in 50 of 7,903 consecutive laparotomies performed at the Henry Ford Hospital, an incidence of 0.64 per cent.

Inguinal and femoral herniotomies, strictly speaking, are laparotomies, but they are not included in this compilation. The above figure is not a true index of the frequency of this condition. The actual percentage of occurrence can be arrived at only by including those cases which leave the hospital with their wounds in an apparently satisfactory condition, but who subsequently develop postoperative ventral hernias. In the latter group, some degree of wound separation, varying all the way from the protrusion of a small tag of omentum through the peritoneum and posterior rectus sheath, to the disruption of all the layers of the abdominal wall except the skin, must have occurred during the immediate postoperative state. That this condition should pass unnoticed is not surprising when it is considered that the majority of cases of complete disruption are not recognized or even suspected until the skin gives away, and a viscus protrudes.

It is our practice to perform immediately secondary closure on all cases. This is possible even in very sick patients, if they are moved to the operating room and operated on in their own beds. The use of local novocaine infiltration plus subcostal block provides adequate relaxation if general or spinal anesthetic is contraindicated by the patient's condition. In this series, 49 of the 50 cases, or 98 per cent, had a secondary closure done.

The one patient on whom operation was not done was believed moribund at the time wound rupture occurred. Conservative treatment of the wound by covering the protruding viscus with sterile

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gauze and strapping the wound edges together with flamed adhesive resulted in recovery, but with the formation of a very large postoperative ventral hernia. Only the 49 patients on whom operation was done are considered in this review.

AGE GROUP BY DECADES

TABLE I

DECADE	NO. PATIENTS	DECADE	NO. PATIENTS
1. 0- 9	0	5. 40-49	13
2. 10-19	2	6. 50-59	10
3. 20-29	6	7. 60-69	3
4. 30-39	14	8. 70-79	1
	22		27 Total, 49

The ages ranged from 14 to 72 years, the average age being 43.3 years. Over 75 per cent of the patients were in the fourth, fifth, and sixth decades, i.e., between the ages of 30 and 60 years, the period of life when individuals are most likely to be subjected to operations. Thus age alone does not appear to have a bearing on this condition.

SEX

TABLE II

Males	27	55%
Females	22	45%

Table II shows a slight preponderance of males, but not enough to be significant.

SEASONAL OCCURRENCE

TABLE III

WINTER		SPRING		SUMMER		FALL	
December	3	March	9	June	2	September	5
January	4	April	7	July	1	October	4
February	4	May	4	August	2	November	4
Total	11—22%		20—40%		5—10%		13—25%

Sokolov, of Leningrad, reports that in Russia the majority of wound ruptures take place during the winter. His explanation is that during this season, the abdominal musculature is not so well developed owing to inactivity and a tendency to food deficiency. A study of Table III shows that almost as many wound ruptures occurred in spring as in autumn and winter combined, and that the incidence in spring was four times the summer rate. This is very suggestive of the importance of respiratory diseases as a causative factor.

INCISIONS

TABLE IV

UPPER ABDOMINAL		LOWER ABDOMINAL	
Paramedian	16	Paramedian	23
Linea alba	6	Rectus splitting	0
Linea alba and T-extension	3	Pfannenstiel	0
Rectus splitting	1	McBurney	0
Total	26—53%	Total	23—47%

In upper abdominal incisions, there were 26 ruptures, or 53 per cent of the total, and in the lower abdominal incisions 23 ruptures, or 47 per cent of the total. The difference here is so slight as to appear insignificant. These figures closely approach the findings of Sokolov, who reviewed 730 cases and reported 57 per cent occurring above and 43 per cent below the umbilicus.

In this clinic, the paramedian incision with reflection of the rectus muscle outward is employed in biliary tract surgery, and incison through the linea alba is used for gastroduodenal operations. Though the former incision is utilized much more frequently, the latter has definite advantages when speed is indicated, since the abdominal cavity is entered directly through an avascular area. Another point in its favor is that none of the tissue planes are entered, thus safeguarding against loss of tissue should wound infection supervene. Healing of the structures of the linea alba is often delayed as a result of the poor blood supply in this area. Some of the difficulty may be overcome by imbricating the layers, a maneuver easy to carry out in cases requiring stomach and duodenal operations, since there is usually an associated weight loss. The poor repute which this incision bears is not enhanced by reference to Table IV where it is found that 9 of the 26 upper abdominal ruptures, or 34.6 per cent, occurred in sections through the linea alba. In splenectomy, the T-shaped incision, vertically through the linea alba and transversely across the left rectus muscle, is frequently utilized because it gives an excellent exposure of the splenic pedicle. The rectus muscle is seldom split, because of the inevitable loss of tone of the medial fibers, an objection which may have more theoretical than practical value. The transverse and the subcostal incisions of Kocher have been employed with satisfactory results, but so infrequently that their value cannot be estimated.

In the lower abdomen, the so-called right rectus incision with reflection of the rectus muscle fibers outward is the incision of choice for pelvic surgery and appendicitis operations when abdominal exploration is indicated. The McBurney incision for acute appendicitis is favored here because of the excellent results obtained. The approach to the appendix is more direct than that afforded by the right rectus incision, thereby minimizing soiling of the peritoneal cavity in

infected cases. Further, when drainage is necessary, the drainage tube can be placed so as to be largely extraperitoneal, while that part within the peritoneal cavity is placed, not through a coil of intestine, but down along the parietal peritoneum, thus lessening the number of peritoneal adhesions and postoperative obstructions. Another reason for the use of the McBurney incision is the fact that the recurrence of both postoperative wound ruptures and postoperative hernias, even in infected cases, is so small as to be almost negligible. The objection of insufficient exposure may be invalidated if the Weir extension is employed. The wisdom of this choice is emphasized by the fact that none of the McBurney incisions broke open during the postoperative state. The split rectus and Pfannenstiel incisions are infrequently used.

DURATION OF OPERATIONS

TABLE V

DURATION	NO. PATIENTS	DURATION	NO. PATIENTS
½ hour	1	1½ hours	6
¾ hour	7	1¾ hours	5
1 hour	12	2 hours	14
1¼ hours	2	2 hours, plus	2
Total	22—45%		27—55%

Table V shows that postoperative wound rupture occurs even after short operations. In 20 cases, or nearly 40 per cent, the operating time was not longer than an hour. Assuming that the operator is skilled, the time consumed in performing an operation is a rough index of its severity or at least of the difficulties encountered. In this series, the time factor appears to exert a definite influence on the condition under discussion, since in 55 per cent of the cases, the operations lasted one and one-half hours or more, and the average operating time was one and one-quarter hours.

MULTIPLE OPERATIONS

TABLE VI

	NO. OF CASES	PERCENTAGE
Single operations	13	26.5
Multiple operations	36	73.5

The performance of more than one operative procedure at a time has an undoubted bearing on the increase of postoperative wound rupture. This is attested by the fact that in this series, 36 of the 49 patients, or 73.5 per cent, were subjected to multiple operations. In some instances, this additional work consisted only of removal of the appendix. When more than one procedure is carried out, the operat-

ing time is prolonged and trauma increased, since it is frequently necessary to enlarge the incision or institute vigorous retraction in order to obtain adequate exposure.

CLASSIFICATION OF OPERATIONS

TABLE VII

			PERCENTAGE
PELVIC			
Nonmalignant	12		
Malignant	2		
Total		14	28.6
GALLBLADDER			
Cholecystectomy alone	2		
Cholecystectomy with appendectomy	7		
Cholecystectomy with drainage pancreas	1		
Total		10	20.4
APPENDECTOMY, Right rectus		8	16.3
GASTRODUODENAL			
Malignant	4		
Nonmalignant	3		
Total		7	14.3
SPLENECTOMY		4	8.2
ABDOMINAL EXPLORATION in Cirrhosis of Liver with Ascites		3	6.1
CARCINOMA COLON		2	4.1
UMBILICAL HERNIA		1	2.0
Total		49	

Worthy of note are the comparatively few carcinoma cases whose wounds disrupted, only 8, or 16.3 per cent, of the series. This figure is low compared with 28 per cent reported by Colp, and 40 per cent reported by Stair and Nelson. The high increase of ruptures in cases of ascites is in agreement with other observers. The relatively large numbers of wound separations following splenectomy must be considered as an indictment of the use of the T-shaped incision. The eight cases of disruption after right rectus appendectomies in a small series compares favorably with a larger group of McBurney appendectomies without a single instance of wound rupture.

METHOD OF SUTURING

Our routine closure of abdominal wounds, except in clean cases in which silk is used, is done with continuous No. 1 plain catgut for the posterior rectus sheath and the peritoneum, and interrupted figure-of-eight No. 1 chromic catgut sutures for the anterior rectus sheath. The subcutaneous tissues are closed with interrupted sutures of No. 1 plain catgut, and the skin margins are brought together with interrupted sutures of fine black silk. This procedure was carried out in

all but two cases of this series, when No. 1 chromic catgut was substituted for No. 1 plain catgut in the suture of the posterior rectus sheath and the peritoneum.

In certain clean cases, all layers are sutured with silk. It is interesting to note that there were no cases of wound disruption in which silk was used. Unfortunately, the total number of cases in which silk was used is not available for discussion at this time so that no deduction can be drawn. In consideration of the relative merits of these suture materials, it should be noted that silk is used only in the most favorable cases. It is evident that care in suturing is of more importance than the suture material used. A meticulous approximation of the peritoneum and posterior rectus sheath so as to prevent the insinuation of omental tags is the first requisite for a solid wound. When wound rupture occurs, however, from no other apparent reason than disintegration of catgut, the suggestion that the use of silk sutures might have avoided the catastrophe is bound to arise. Coaptation of the wound edges should be the objective, but strangulation of the tissues by tight suturing must be avoided.

STAY SUTURES

TABLE VIII

	TOTAL NO. CASES	NO. CASES STAY SUTURES	PERCENTAGE
Upper abdomen	26	13	50.0
Lower abdomen	23	5	22.0
	49	18	36.5

Stay sutures were used in 36.5 per cent of the series. They were made use of in 50 per cent of upper abdominal and in 22 per cent of lower abdominal incisions. These findings are in accordance with the procedure at this hospital where stay sutures of silkworm-gut are used in upper and lower abdominal incisions in about the above ratio. These sutures are inserted through the skin, subcutaneous structures, and anterior rectus sheath only. The value of stay sutures used in this manner is problematical. Adequate support can be given only when stay sutures are inserted through all the layers of the abdominal wall, including the peritoneum and posterior rectus sheath. This procedure, however, has the theoretical disadvantage of acting as a possible source of contamination to the peritoneal cavity when the sutures are removed, owing to the frequency with which the so-called stitch abscess forms around the stay sutures. For this reason, most surgeons are content to include only the anterior rectus sheath, or at most only the muscle and its sheath. Kennedy is the great proponent of the through-and-through stay suture. His results are so excellent that the method warrants consideration. When postoperative dis-

ruption of a wound does occur, stay sutures play an important part in preventing evisceration and in minimizing exposure of the abdominal contents. This benefit alone merits the continuance of their use, even if they have no value in preventing the accident.

DRAINAGE

Peritoneal drainage was established by deep drains in 19, or 38.5 per cent, of the cases. In all but two instances, or in 95 per cent, the drains were brought out through the original incision. This raises the question of the value of stab drains, which, theoretically at least, ought to be preferable to drains placed in the suture line. The decision as to the drainage site should be decided by the directness of approach to the infected area. A drainage tube through the suture line going directly down to the region requiring its use has obvious advantages over oblique drainages through a stab wound. As for example, drainage of the common duct is better through a paramedian incision than through a stab wound at the outer border of the rectus muscle. On the other hand, better drainage of the pelvis can be obtained by introducing the drain through a suprapubic stab wound or through the posterior fornix, rather than through a McBurney incision.

POSTOPERATIVE COURSE

TABLE IX

COMPLICATION		NO. OF CASES	PERCENTAGE
Distention		28	57.0
Coughing and sneezing		22	45.0
Bronchopneumonia	9		
Bronchitis	4		
Lobar pneumonia	1		
Atelectasis	1		
Wound infection		10	20.0

The postoperative course of the patient whose wound ruptures is seldom uncomplicated. Even in those cases where rupture occurs without apparent warning, a review of the hospital records will show that the temperature and pulse remained elevated beyond the normal reaction period, but not enough to excite suspicion that all was not well. Vomiting when it does occur is frequently evidence of separation of the peritoneum and posterior rectus sheath, and is occasioned by the accompanying partial intestinal obstruction. Thus, it is an effect rather than a cause. The importance of respiratory complications as a factor is emphasized in Table VIII. Here it is shown that coughing and sneezing were recorded as a postoperative complication in 22 patients, or 45 per cent of the total number. Of these patients, 9 had bronchopneumonia; 4, bronchitis; 1, lobar pneumonia; and 1, atelectasis. Distention was pronounced in 28 cases, or 57 per cent,

but it is such a common postoperative complication that its rôle as a causative agent is difficult to evaluate. Gross wound infection, either primary or secondary to intraabdominal contamination, was observed in 10 cases, or 20 per cent, and in all instances was associated with sloughing of the anterior rectus sheath.

DAY OF POSTOPERATIVE WOUND SEPARATION

TABLE X

DAY	NO. OF PATIENTS	PERCENTAGE
6	10	20.0
7	11	22.5
8	11	22.5
9	6	12.0
—	—	77.0
	38	
4th, 5th, 12th, and 13th days	2 each	
2nd, 11th, and 14th days	1 each	

The earliest postoperative wound separation was observed on the second day following operation, and the longest interval between operation and disruption was 14 days. The average was 7.6 days. About an equal number of ruptures took place on the sixth, seventh, and eighth postoperative days. If the ninth day is included in this group, a total of 38 cases, or 77.5 per cent of the cases, occurred in this four-day period. Only 5 cases, or 10 per cent, happened before the sixth day, and only 6 cases, or 12 per cent, after the ninth day. The above figures must indicate only the approximate time the peritoneum and posterior rectus sheath give away. They actually designate the day on which separation of the skin edges and evisceration take place.

CLINICAL FEATURES

The absence of shock when rupture takes place is noteworthy. In fact, it is not uncommon for the patients to state that they feel relieved when the wound margins separate. The paucity of signs may be attributed in part to the gradual onset of the condition, and in part to the fact that it may be masked by other complications. Frequently the first evidence of disruption appears on the same day as the skin sutures are removed from an apparently healthy wound. The appearance of a considerable amount of blood-stained serum on the dressings of a wound previously dry is pathognomonic of rupture. On inspection of the wound, a degree of separation is observed varying all the way from the appearance of a portion of omentum at one angle of the wound, to complete separation of the wound margins and partial evisceration.

Postoperative wound ruptures associated with frank wound infection presents a different picture. Here the dramatic onset of the

apparently clean case is lacking, and there is, instead, a more gradual onset. In a typical case, the infection attacks the subcutaneous tissues where it forms an abscess which drains through the skin incision. If the infection is progressive, sloughing of the anterior rectus sheath occurs, followed by separation of the deep layers.

The primary causative factor in the group where there are no signs of gross infection is not clear. The secondary factors, such as inaccurate suturing, faulty suture material, poor physical condition, coughing, distention, etc., must be present in large numbers of patients whose wounds proceed to complete and satisfactory healing. Infection without gross evidence undoubtedly accounts for some cases, but there is still a group where a satisfactory explanation is wanting. The operative findings at the secondary closure are interesting. There are three outstanding features: disappearance of catgut, edema of the abdominal wall, and lateral retraction of the posterior rectus sheath and peritoneum. As early as the sixth postoperative day, it is surprising to find that even twenty-day chromic sutures have entirely disappeared or are represented by only a few frayed strands. The edema of the wound is out of proportion to that which occurs in connection with the inflammatory reaction incidental to normal healing. On palpation, the wound edges have a hard rubbery consistency. This swelling of the wound margins considered in conjunction with the free outpouring of serum at the time of the rupture indicates an excessive tissue response. The whole picture is that of an inflammatory reaction characterized by excessive edema and undue outpouring of serum. This phenomenon suggests an allergic reaction. That infection is not always present is attested by the fact that in some cases primary healing takes place after secondary closure.

CAUSE OF RUPTURE

TABLE XI

IMPRESSION OF SURGEON PERFORMING SECONDARY CLOSURE

	NO. CASES	PERCENTAGE
Coughing	11	27.5
Vomiting	8	20.0
Infection	8	20.0
Getting out of bed too soon	3	7.5
Poor physical condition	3	7.5
Peritonitis	2	5.0
Omental wedge	2	5.0
Poor structures	1	2.5
Faulty catgut	1	2.5
Broken stay sutures	1	2.5
Total	40	
Unrecorded	9	
Total	49	

In 40 of the 49 cases, the surgeon performing the secondary operation recorded his impression of the cause of the catastrophe. Heading the list is coughing in 11 cases, or 27.5 per cent, an observation which again brings attention to the rôle played by respiratory infections. Gross wound infection was noted in 8 cases, or 20 per cent, and in only 5 per cent of the patients was there evidence of peritonitis. The plastic exudate incidental to peritoneal infection causes the viscera and omentum to become adherent, thereby lessening the tendency to evisceration. It is surprising, in view of current opinion to the contrary, that poor physical condition was considered responsible in only 3 cases, or 7.5 per cent. The blood Wassermann reaction was negative in all of the patients.

THE SECONDARY CLOSURE

TABLE XII

SUTURE MATERIAL	NO. CASES	PERCENTAGE
Silver wire alone	34	70.0
Catgut alone	1	2.0
Catgut plus silver wire	14	28.0
Total silver wire	48	98.0
Total catgut	16	30.0

Through-and-through sutures of silver wire were used to bring wound edges together in 70 per cent of the cases. In only 15 patients, or 30 per cent, was it possible to attempt layer closure of the abdominal wall with catgut, and in all but one case, additional reinforcement with through-and-through sutures of silver wire was necessary. Lateral retraction of the posterior rectus sheath and peritoneum prevents satisfactory closure. Only rarely is it possible to attempt separate suture of this structure owing to its friability. This observation that postoperative ventral hernia after secondary closure is the rule rather than the exception serves to draw attention to the important part played by the posterior rectus sheath in maintaining the integrity of the abdominal wall.

MORTALITY

TABLE XIII

DURATION OF LIFE AFTER SECONDARY CLOSURE	NO. CASES
1-24 hours	12
3 days	1
5 days	2
14 days	1
22 days	1
Total	17—34%

There were 17 deaths out of the 49 patients on whom secondary closure was done. This gives a mortality rate of 34 per cent.

It is instructive to note that in 12 of the 17 patients, or 70 per cent, death took place within 24 hours of the secondary closure. This may be taken as an indication of the general condition of the patient at the time of secondary closure. It also serves to substantiate the impression that the real cause of wound rupture lies more in the pathologic condition requiring surgical interference and in the individual's reaction to the operation and its complications, than in faulty methods of suturing. At the same time, this high mortality occurring within twenty-four hours of performing secondary closure brings up the question of the advisability of suturing all cases of wound disruption immediately, unless obstruction is present.

CAUSE OF DEATH

TABLE XIV

Ileus	6	Myocardial insufficiency	2
Peritonitis	4	Pulmonary embolism	2
Pneumonia	4	Pancreatitis	1

Except for the patient with pancreatitis, the cause of death was attributed to complications developing during the postoperative course. It must be admitted, however, that certain of these patients might have recovered had their wounds not broken down.

SUMMARY

1. The incidence of postoperative wound separation in 7,903 consecutive laparotomies was 0.64 per cent.

2. Of the 50 cases, 49 had secondary closures.

3. A seasonal variation is shown in our series.

4. Multiple operations had been performed in 73.5 per cent of the cases.

5. In 55 per cent of the cases, the operation had lasted one and one-half hours, or longer.

6. Stay sutures of silkworm-gut or silver wire were used in 36.5 per cent.

7. The clinical picture in the noninfective cases suggests an allergic reaction.

8. The mortality following secondary closure was 34 per cent.

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THE APPLICATIONS OF CAVITY GRAFTING

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THE most important basic principle in the reconstructive surgery of superficial skin defects is the diagnosis of the amount of epithelium lost and its successful replacement by a covering which can adapt itself to its new surroundings as far as possible, anatomically, functionally, and esthetically. With superficial lesions, such as burns, contractures, industrial accidents, congenital deformities, and so forth, this has long been done satisfactorily in a variety of ways, the particular method used depending largely upon the type of lesion, the expected cosmetic result, and the experience of the particular surgeon. The simplest method is undoubtedly by means of a free skin graft cut with a razor and applied under pressure directly to the denuded area after suitable excision of granulomatous tissue and scar. If the graft is well cut, the correct pressure applied to it, and the ordinary surgical principles of strict asepsis and hemostasis enforced, a complete take results in such a very high percentage of cases that one can only be impressed with the essential vitality of epithelium under what are sometimes very adverse surroundings.

Not all superficial defects, however, are confined to the external surface of the body. Many of them involve body cavities, such as the mouth, nose, orbit, or ear, with loss of lining skin and mucous membrane, and present problems of replacement crucial to the success of any repair. This was the type of injury which during the war offered grave difficulties to reconstructive surgeons until Esser showed how free skin could be successfully grafted as a lining membrane into the mouth, where it would endure without harm to itself under conditions normally quite foreign to it. By introducing from below the chin a block of moldable material covered with Thiersch graft, and completely burying it in the subcutaneous tissues, he was able to produce a satisfactory skin-lined cavity which when opened into from above reproduced a destroyed buccal sulcus very satisfactorily. This revolutionary idea was immediately seized upon by Gillies, who with his associates at Sidcup developed what is now known as the "Epithelial Inlay."

The essential modification of the Esser method consisted in the introduction of the skin graft directly into the mouth, where it was

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found to take in an apparently septic cavity and in the presence of salivary secretion. The method has now an increasingly wide application in the reparative surgery of civil life, and in this communication I propose to show some results obtained by it, and to demonstrate its use in some unusual situations.

PRINCIPLES OF CAVITY GRAFTING

Wherever it is necessary to construct a new subcutaneous skin-lined cavity or to reconstruct one which has been destroyed, certain precautions must be observed if the finished product is to endure without subsequent contraction. The subcutaneous cavity must be made somewhat larger than the ultimate size required; it must be overdistended with a block of modeling compound accurately molded to the size of the cavity; the mold must be entirely covered by a one-piece Thiersch graft so that a complete take can be expected without breaks in continuity, and with as few epidermal appendages as possible; the cavity must be maintained distended by the original mold for a period well beyond the normal contractile phase of grafted skin. It is most important that this overdistention be carried out for a period varying from six weeks to four months, otherwise even in the presence of a perfect take, serious contraction will occur. Ill effects do not follow if a mold is buried under such conditions for long periods, provided some small drain hole is left for the escape of secretions during the healing phase.

THE MOUTH

This represents the most important field for cavity grafting. The conditions in which an epithelial inlay is required in the mouth are many and various, and may be the result of disease, injury, or congenital deformity.

1. Destruction of the buccal sulci due to disease is usually the result of specific or tuberculous ulceration, particularly that due to lupus vulgaris. In both instances the adhesions can be separated and a mobile lip achieved by the introduction of new skin between the lip and the maxilla. On several occasions I have removed and grafted with good results actively ulcerating patches of lupus upon the hard palate and buccal sulci, where other methods of treatment failed. Experience has shown that lupus rarely invades a skin graft even where the removed patch was in a very active condition.

2. Injuries may also cause loss of buccal epithelium with resultant external deformity which can be cured only when the internal adhesions are freed. As a rule this can be done by adjustment of mucous membrane flaps, but extensive losses will require grafting. The alar base tightly adherent to the anterior surface of the upper alveolus can

thus be easily released (Fig. 1). The most frequent field for intrabuccal grafting after injury, however, follows the larger bone grafts to the fractured lower jaw. Side-to-side apposition of the bone graft obliterates the sulcus for such a distance that a stable denture cannot be fitted. Deepening of the sulcus obviates the difficulty and at the same time allows the so-called "flat angle" to be built out to a pleasing contour by an extension on the dental plate (Fig. 2).

3. Occasionally after extraction of teeth in elderly people so much bony absorption takes place in the lower alveolus that the buccal sulcus is too shallow to fit a stable denture. A buccal inlay gives the necessary purchase for satisfactory mastication (Fig. 3).

Fig. 1.—Inlay graft behind the upper lip and left ala, freeing them from attachments to the maxillary alveolus and floor of nose. Result of trauma. *a*, Original condition; *b*, after inlay.

4. The repair of congenital deformities, however, affords the most fruitful field for cavity grafting, particularly in secondary cleft lip and palate and in retrognathism.

In primary operations for cleft palate, it is not often used, though at the suggestion of Sir Harold Gillies, I have grafted the extensive lateral relaxation incisions of the Veau technic, which during the healing process must cause considerable contraction and shortening of the united palate.

In most patients in whom secondary operations for cleft lip are necessary, the upper buccal sulcus must be deepened in order to free the short, tight, adherent, and retracted upper lip, and to bring it forward in apposition with the lower lip. This compensates for the

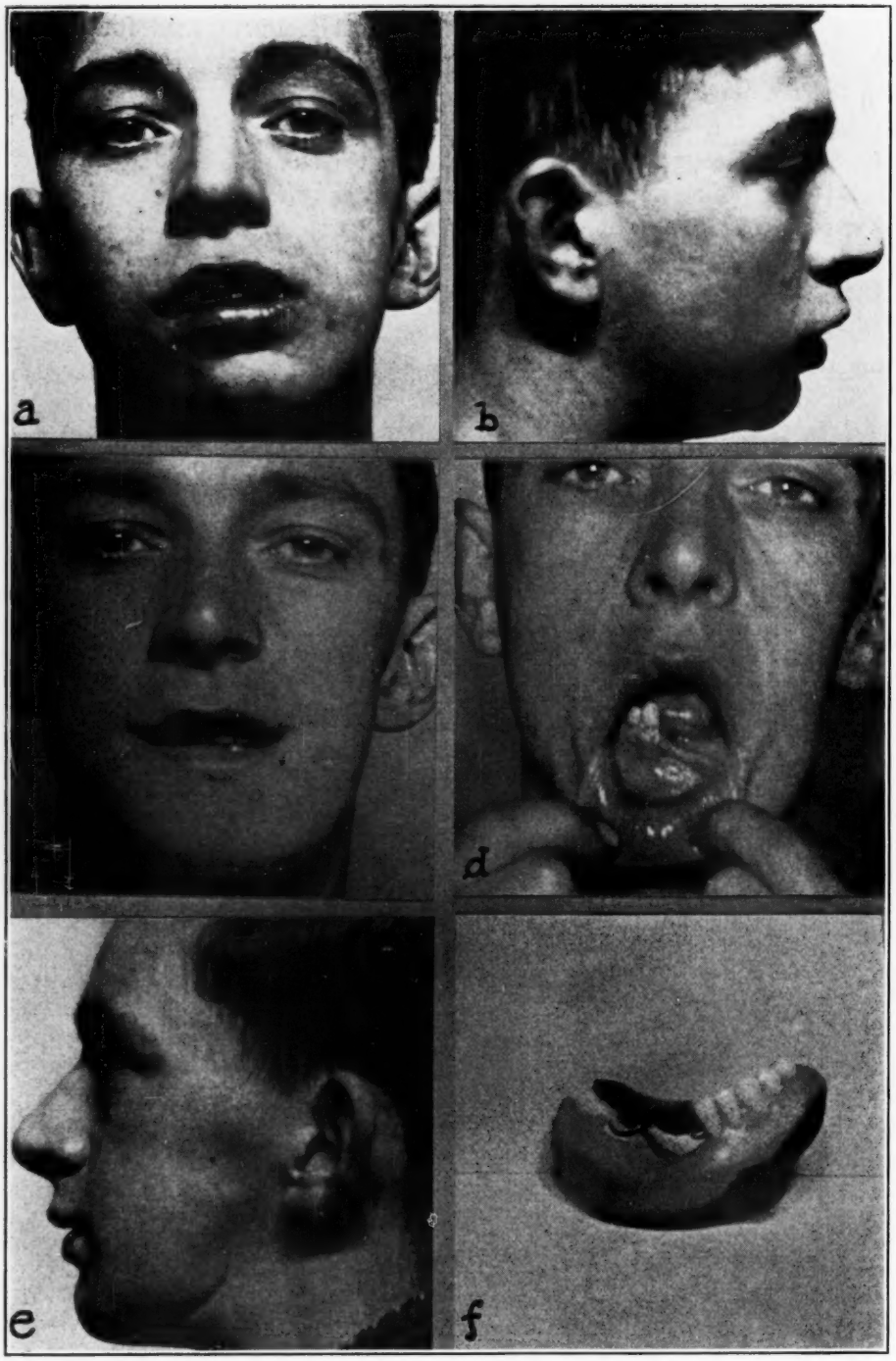
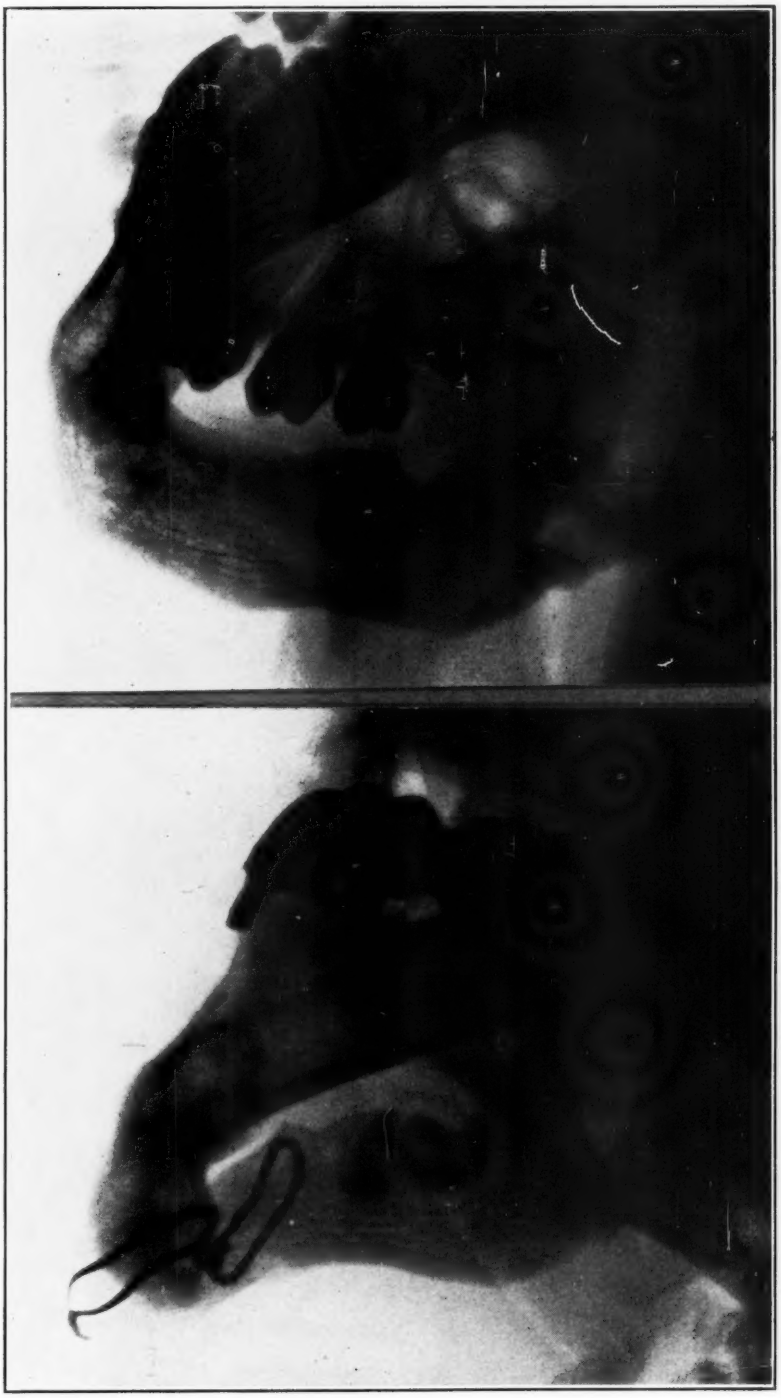


Fig. 2.—Inlay graft to lower buccal sulcus, following extensive bone graft for osteomyelitis of jaw. This enabled a stable plate to be fitted and the contour of the jaw improved. *a* and *b*, Original condition showing maloccluded and retroposed lower jaw; *c* and *e*, condition after iliac bone graft and inlay for fitting of dental plate; *d* and *f*, the skin-grafted cavity and the built-out plate which occupies it; *g* and *h*, x-ray of bone-grafted jaw showing splint for inlay graft cemented to teeth.



g.

h.

Fig. 2.—(*See opposite page for legend.*)

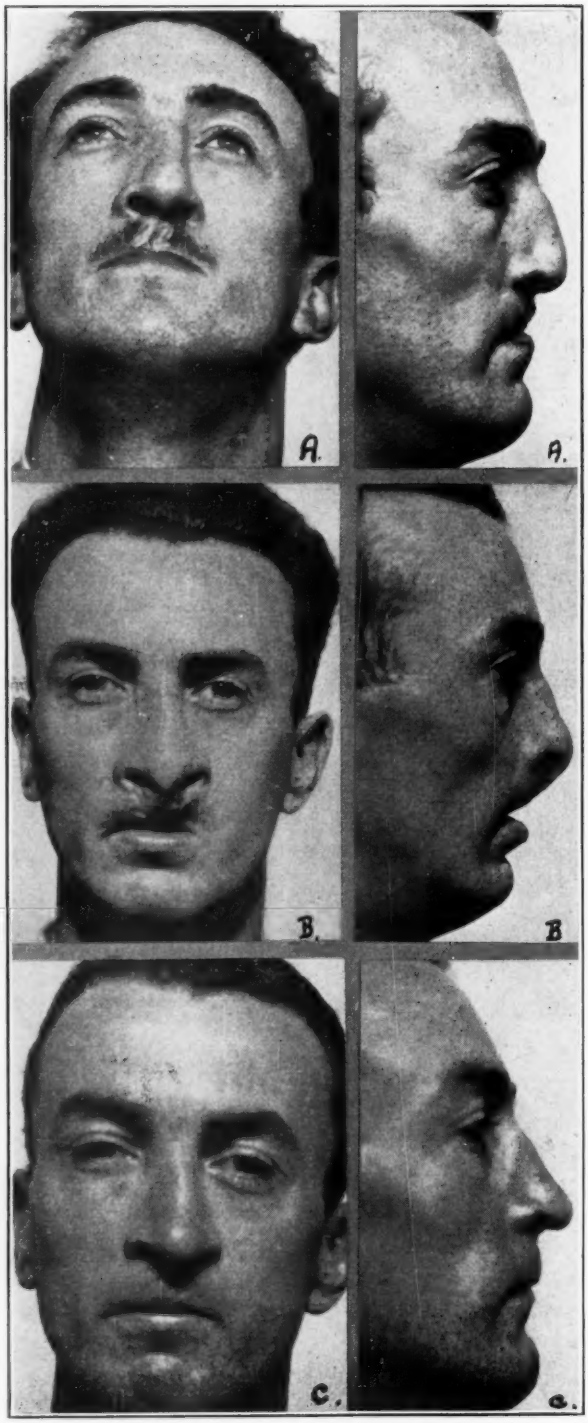


Fig. 3.—Secondary cleft lip and palate, showing effect of repair of lip and postlabial inlay graft and Abbé's operation. *A*, Original condition; *B*, postlabial inlay *C*, final result after repair of lip and straightening of nose.

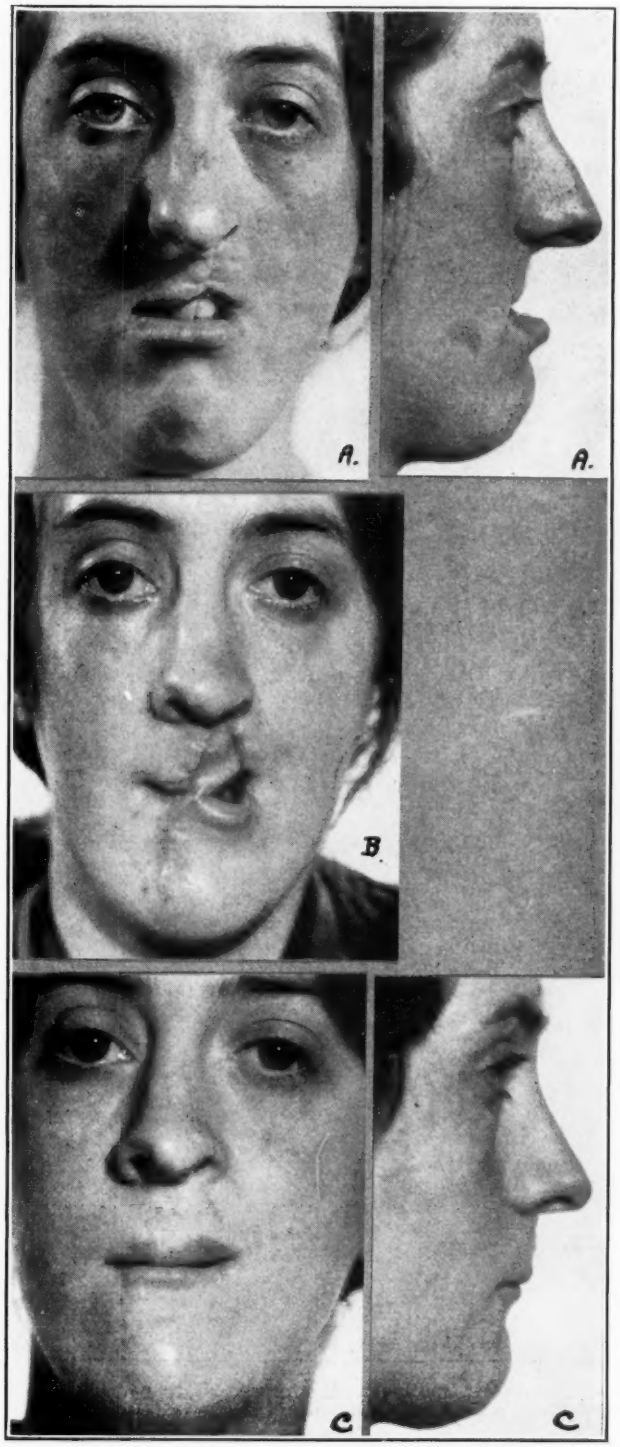


Fig. 4.—Secondary cleft lip and palate showing effect of repair of lip by postlabial inlay graft and Abbé's operation. *A*, Original condition; *B*, postlabial inlay with first stage Abbé's operation; *C*, final result after second stage Abbé's operation and cupid's bow operation.

maxillary deformity which follows many of the older palate operations. The effect upon the external contour is often dramatic, and there is no question that this operation must frequently serve as the essential basis for any successful repair (Figs. 3 and 4).

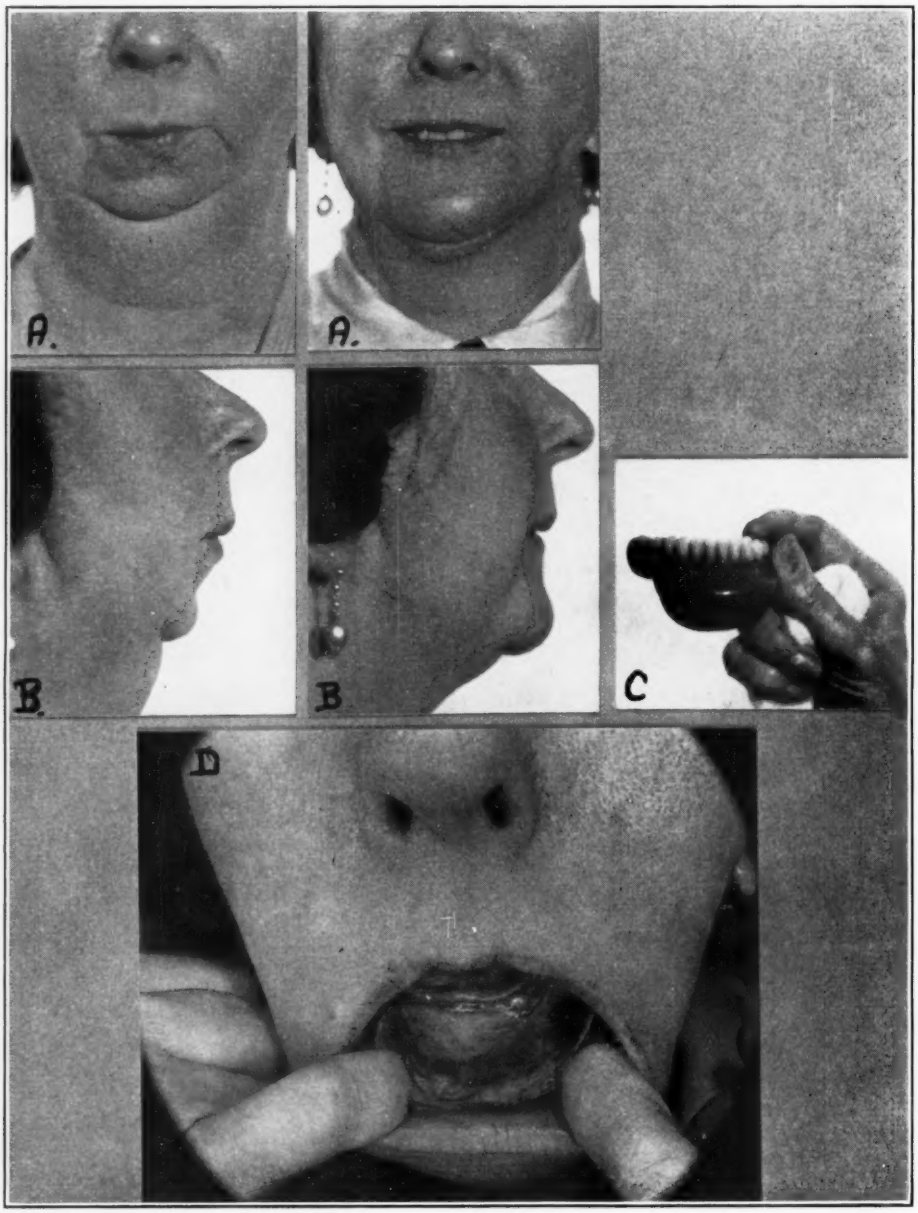


Fig. 5.—Congenital retrognathism, showing extent to which chin can be advanced by large inlay graft and dental appliance. *A* and *B*, Before and after inlay; *C*, denture; *D*, epithelial pocket.

As is well known, the Gillies operation, designed for the very short palate, requires the introduction of a skin graft into the raw area caused by the separation of the soft from the hard palate.

5. In retrognathism a most satisfactory compromise can be effected simply by means of a large buccal inlay, the soft tissue of the chin being brought forward into excellent position and maintained there by a vulcanite extension of the lower denture. The complicated and none-too-satisfactory operation of bilateral bone grafting is thereby avoided (Fig. 5).

TECHNIC

As a preliminary to cavity grafting in the mouth and nose, it is necessary to work in close cooperation with a dentist skilled in the making of splints and prosthetic appliances, and in this I have fortunately had the help of Mr. E. A. Hardy, to whose ingenuity and patience I am deeply indebted. Where the lower buccal sulcus has been lost and the patient has standing teeth, a splint of the metal cap type, together with a "snap-on" removable tray, is constructed and cemented into place. In the case of edentulous patients, a combined upper and lower spring retention apparatus of the type illustrated is satisfactory (Fig. 6). When the preliminary dental work is completed, the lip is separated from the anterior surface of the maxilla or mandible as extensively as is required, care being taken to overdo the separation and to create a larger cavity than will ultimately be required.

An accurate and easily removable mold of Stent's dental compound is then made of the cavity in such a way that the retaining tray attached to the splint presses it firmly into place and overdistends the cavity. When this is complete a one-piece Thiersch graft is cut as thinly as possible from the inner aspect of the arm and applied raw surface outward to the mold. The mold and its surrounding graft are then quickly placed in position in the cavity, and the tray fixed on. An elastoplast fixation externally helps to keep the whole firm. The immediate after-care is simple and is merely directed toward keeping the mouth clean with mouth washes, gargles, and sprays. Ordinary diet is encouraged, and the patient should have little distress after the first twenty-four hours. At the end of seven days, the tray and the mold are removed. The cavity is examined and, as a rule, will be found well grafted with possibly one or two tiny spots unhealed. These should be touched with trichloracetic acid fused on a platinum loop. This is done as quickly as possible and the mold replaced. For the next three or four weeks, the cavity is carefully cleaned, first by the dental surgeon and ultimately by the patient, and if necessary the mold renewed—preferably with one made of gutta percha. When the graft is entirely sound, the dental surgeon can fit the permanent denture with an extension on the vulcanite plate to occupy the buccal sulcus to its full depth.

In the case of buccal sulci made after bone grafted fractures of the lower jaw, the deepening may be to a moderate extent and is usually on one or other side of the jaw, as the case demands. The same is true of the elderly edentulous patient with an insufficiently deep buccal

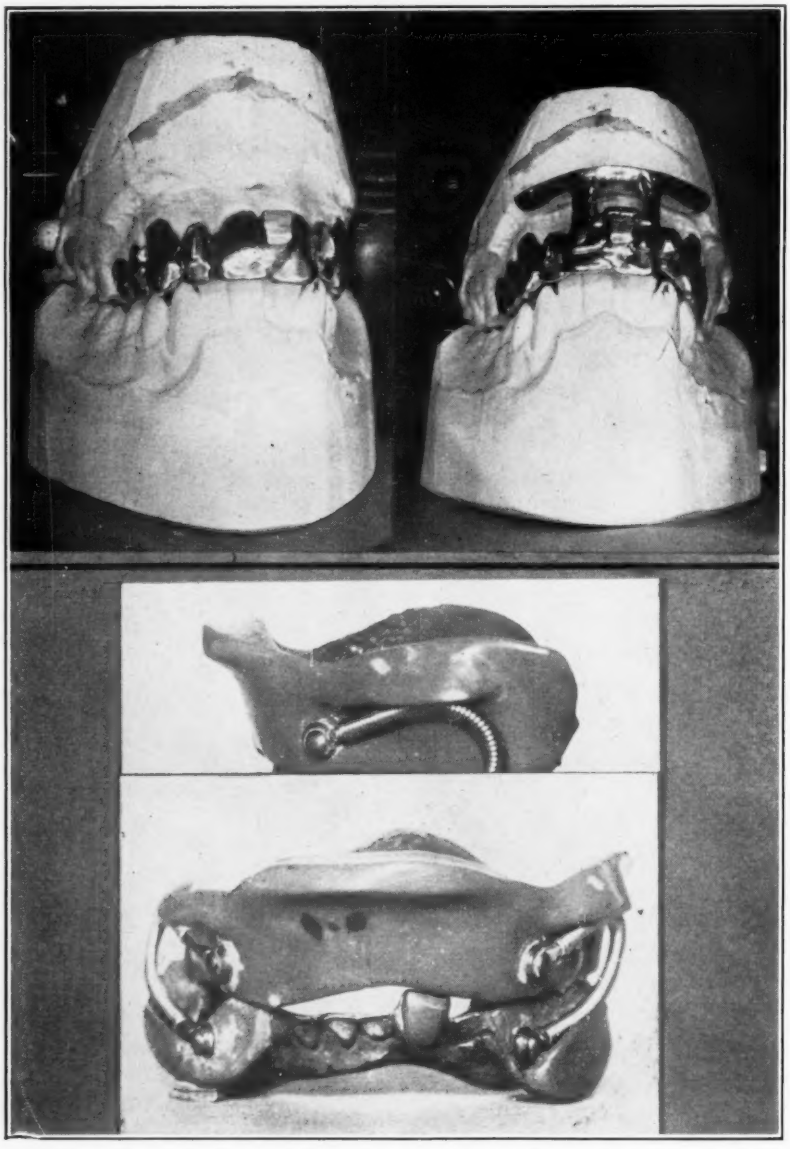


Fig. 6.—*A*, Splint with standing teeth. Dental model showing use of metal cap splint with "snap-on" removable tray where standing teeth exist. *B*, splint without standing teeth. Type of spring retention apparatus used in edentulous patients. (Hardy.)

sulcus for the fitting of a stable plate. In retrognathism, the cavity lies in front of the symphysis and is usually of very large extent (Fig. 7). In the upper lip exactly the same technic is followed, except that

in the case of many secondary cleft lips and palates, it is necessary to carry the incision in the upper sulcus through the nasal floor, along the membranous septum to the tip of the nose in order to obtain elevation of this part as well as of the lip. With standing teeth, the metal cap splint with a removable tray is advisable (Fig. 8).

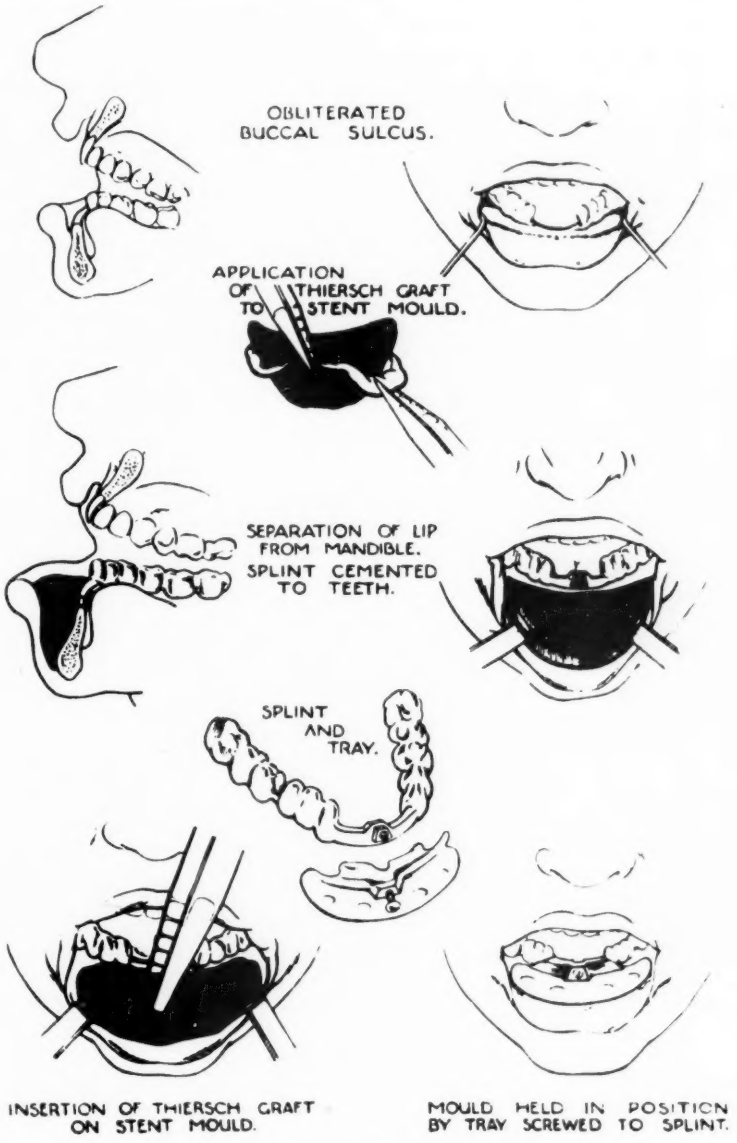

OBLITERATED BUCCAL SULCUS.
APPLICATION OF THIERSCH GRAFT TO STENT MOULD.
SEPARATION OF LIP FROM MANDIBLE.
SPLINT CEMENTED TO TEETH.
SPLINT AND TRAY.
INSERTION OF THIERSCH GRAFT ON STENT MOULD.
MOULD HELD IN POSITION BY TRAY SCREWED TO SPLINT.

Fig. 7.—Diagram—obliterated buccal sulcus.

THE NOSE

A condition extremely difficult to treat by any other method is stenosis of one or both nares. Here an inlay on a stent mold containing a central hole through which the patient may breathe produces excellent

results, but again it is necessary to persist with constant dilatation throughout the period of the contractile phase of the graft (Fig. 9). The most important field, however, for the use of cavity grafting of the nose is unquestionably in specific disease or congenital absence of the septum and supporting structures, and in that deformity called "dish face" which follows severe telescoping fractures of the nasal ethmoid maxillary compound. The uselessness of attempting to restore nasal or facial contour in these conditions by introducing a cartilage graft under the bridge is obvious to anyone who has ever tried

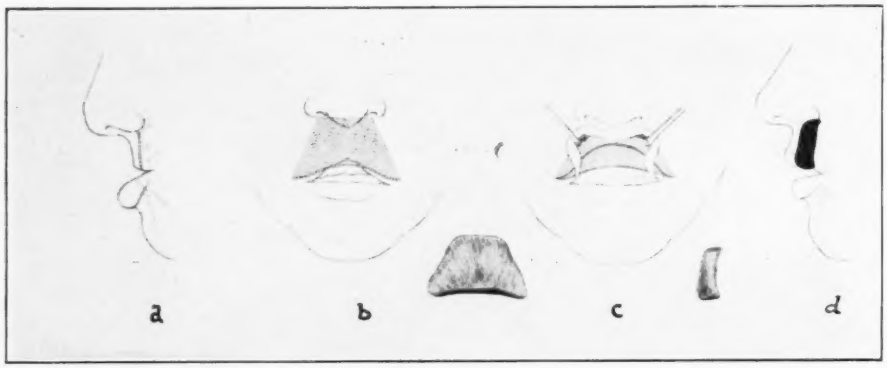


Fig. 8 (*a-d*).—Retroposed upper lip showing extent of mobilization and the type of mold used to bring it forward.

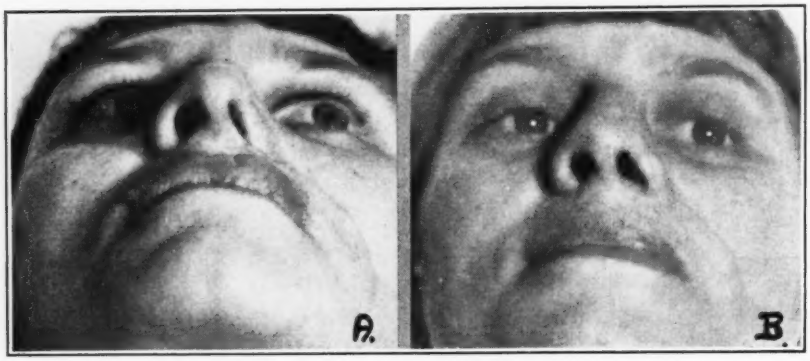


Fig. 9.—*A*, Stenosis of left nostril; *B*, result of treatment by inlay graft on gutta-percha mold.

it. In the specific nose, the essential lesion is loss of nasal mucous membrane, although other structures may be destroyed in addition, and satisfactory reposition cannot be effected unless a new postnasal lining is supplied. The method is practically the same as for the upper buccal inlay, but in this case separation is carried back ruthlessly into the nose (Fig. 10). As a rule the septum has been almost completely destroyed, and the incision in the upper buccal sulcus from canine to canine is deepened upward, leading directly into the nasal cavity formerly occupied by the septum and turbinates. The soft tis-

sues of the nose are mobilized extensively upward as far as the glabella and laterally until the nose can be brought forward well beyond its normal position. Particular attention must be paid to freeing the deep attachments of the alae nasi. I have found that in making the mold for this rather big cavity, it is more convenient to make it in two pieces, one for the nasal cavity proper, extending up over the remains of the nasal bones, and a second mold lying against the first, which occupies the lower half of the cavity and the entrance from mouth to nose. The double block makes for ease of subsequent removal and

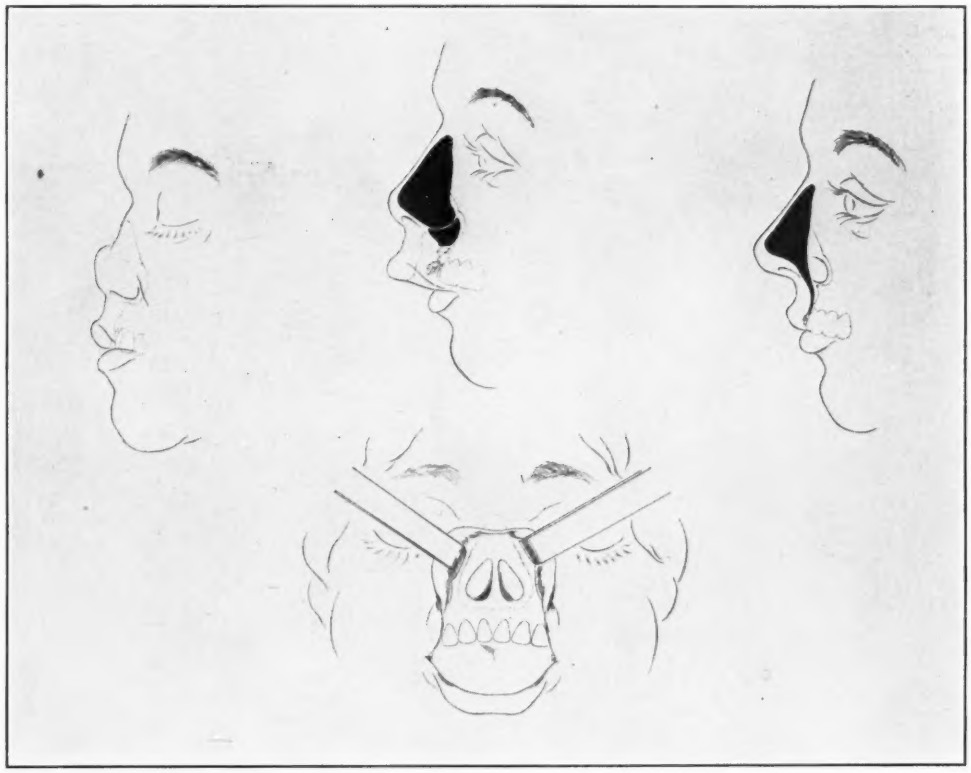


Fig. 10.—Technic of postnasal inlay, showing separation of soft tissues from underlying bones. Overdistention with retention mold and skin graft, and final result.

reintroduction. A large Thiersch graft is, as a rule, required for this type of graft, and again it is obtained from the inner side of the arm, and made as thin as possible in order not to include any epithelial appendages. It is advisable not to distend the skin over the bridge of the nose too much as an extensive inflammatory reaction may be provoked, which will prove troublesome during the postoperative course. (Figs. 11, 12, and 13.)

Postoperative treatment is identical with that of the buccal inlay, and the cooperation of the dental surgeon sought in the after-care of the grafted cavity. Occasionally some amount of suppuration occurs

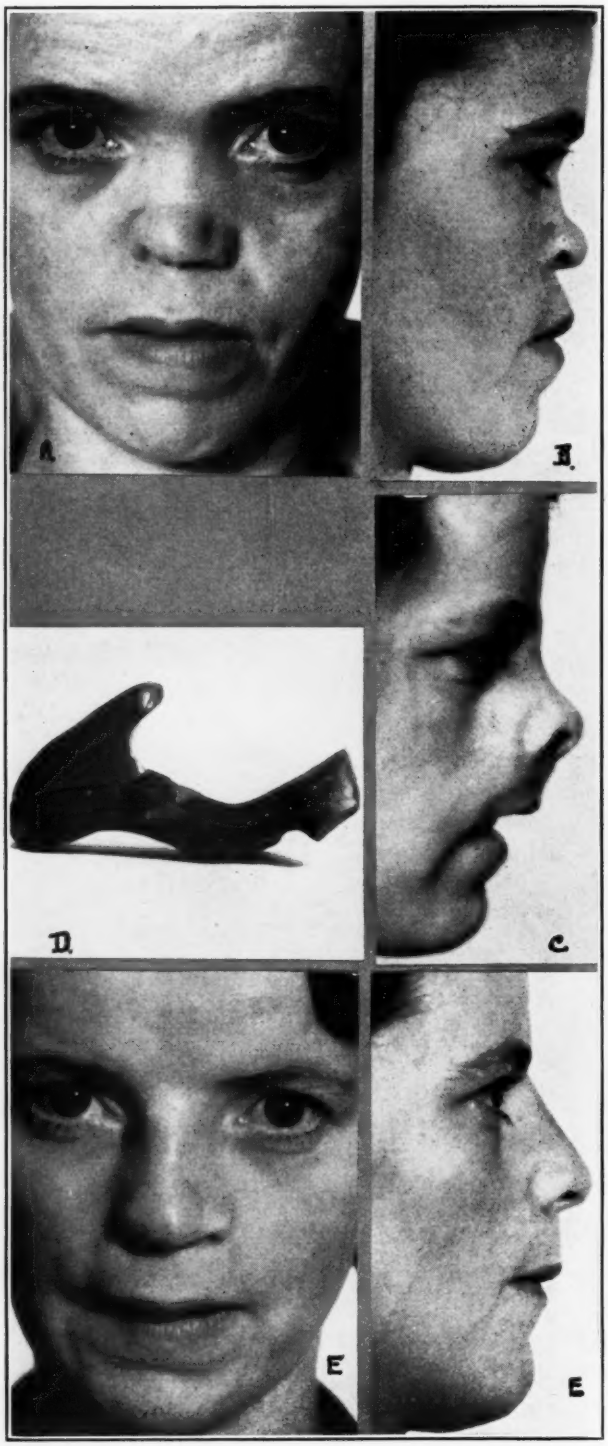


Fig. 11.—*A* and *B*, Congenital specific destruction of nose; *C* and *D*, postnasal inlay and retention apparatus; *E*, final result.

just above the inner canthus of both eyes. This is due either to the mold being too tight or to inadequate drainage at this point. In some cases I have removed the mold and made it smaller, and at the same

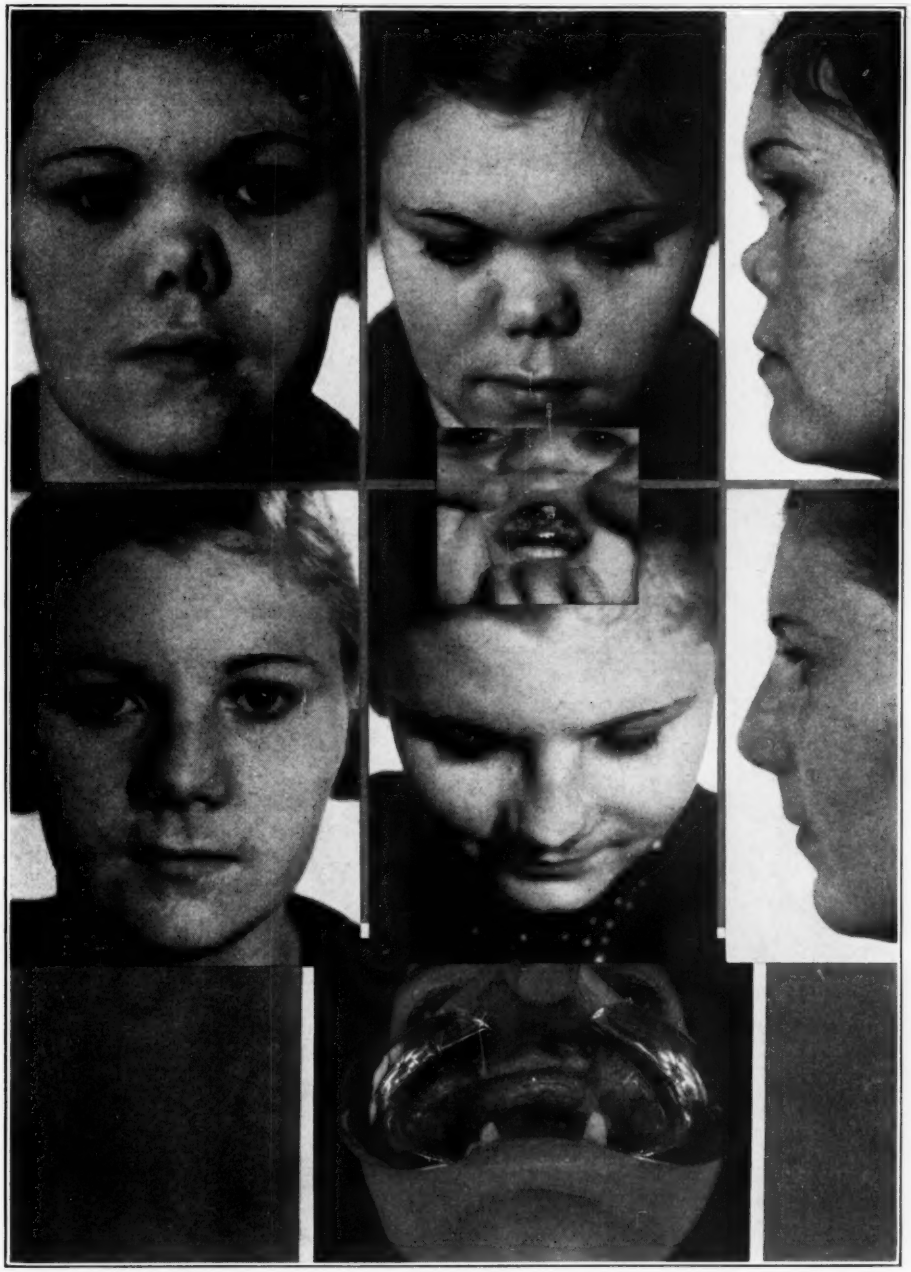


Fig. 12.—*A*, Congenital specific destruction of nose; *B*, result after postnasal inlay; *C*, retention apparatus in situ; *D*, inlay showing communication between nose and mouth.

time punctured the abscess on each side internally; in others I have held on and even allowed an abscess to be opened on the side of the nose. Certainly the worst thing is to remove the stent entirely and

allow the inflammation to subside. Removal of the stent in the early stages for more than a few hours means, of course, the complete contraction of the cavity. When the contractile phase is over, the dental surgeon can then fit a vulcanite retention apparatus which supports the nose permanently. In certain cases, this retention apparatus can be dispensed with and a cartilage graft substituted, while the communication between the nose and the mouth is closed.

THE EYE SOCKET

A common condition after extirpation of the orbit is contraction of the socket to the extent where an artificial shell cannot be fitted or

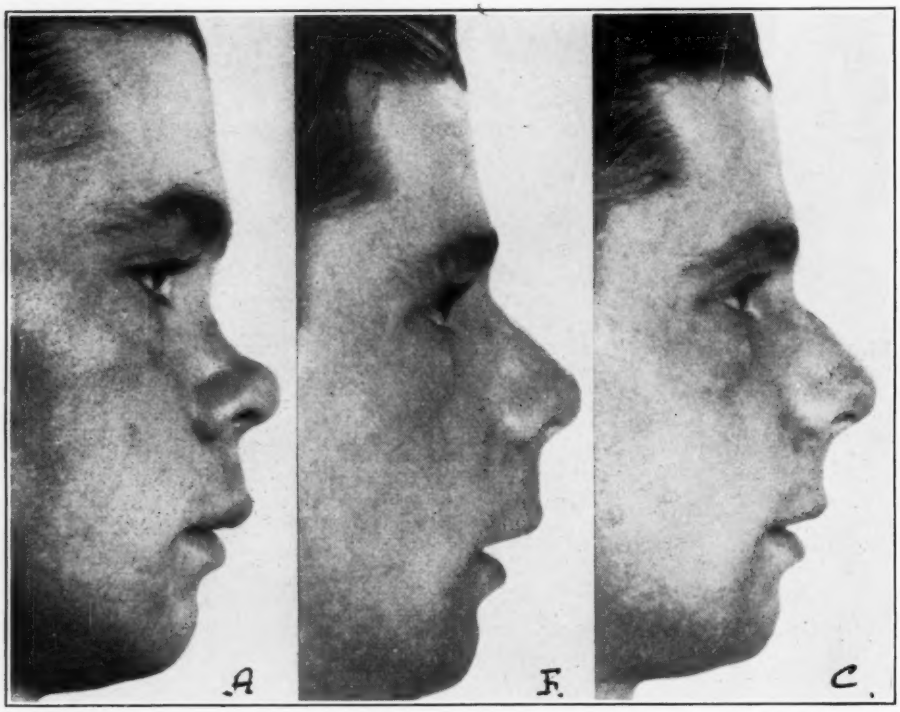


Fig. 13.—*A*, Dish-face deformity; *B*, preliminary overdistention; *C*, final result with dental prosthesis.

retained. Mucous membrane grafts for this condition are, as a rule, totally inadequate and difficult to apply. A simple and very satisfactory application of the epithelial inlay will solve the problem. The mucous membrane of the contracted socket, together with all the scar tissue of the orbit, is dissected out. This includes what little mucous membrane remains on the posterior surface of the lids. A gutta percha mold covered with hairless Thiersch graft is inserted into the cavity and the eyelids carefully sutured together over it. The mold is left in place for a period of four to six weeks, and if possible longer. At the end of this time the lids are separated, the mold removed, and an artificial shell fitted. (Figs. 14 and 15.)

The toilet of the new eye socket is rather important, inasmuch as if neglected, the skin may tend to desquamate and smell rather badly. It should be carefully cleansed twice a day after removal of the shell, wiped out with a little spirit, and lubricated with paraffin and rose water.

THE EAR

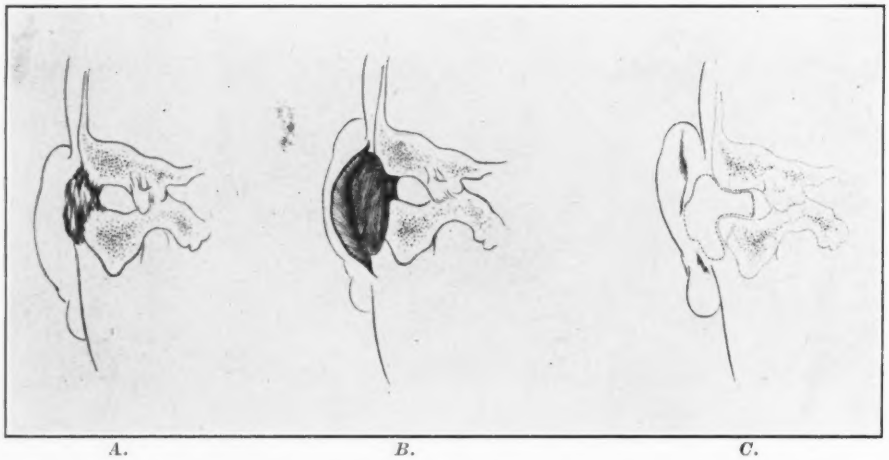
Traumatic stenosis of the external auditory meatus can be easily dealt with by this means. The following case illustrates the method adopted.

Fig. 14.—*A*, Contracted socket; *B*, result of treatment by razor graft; *C*, result of fitting of artificial eye.

Fig. 15.—*A*, Contracted socket; *B*, mold covered with thin razor graft has been in position for two months; lids sewn together; *C*, eye socket after removal of mold; *D*, artificial eye fitted.

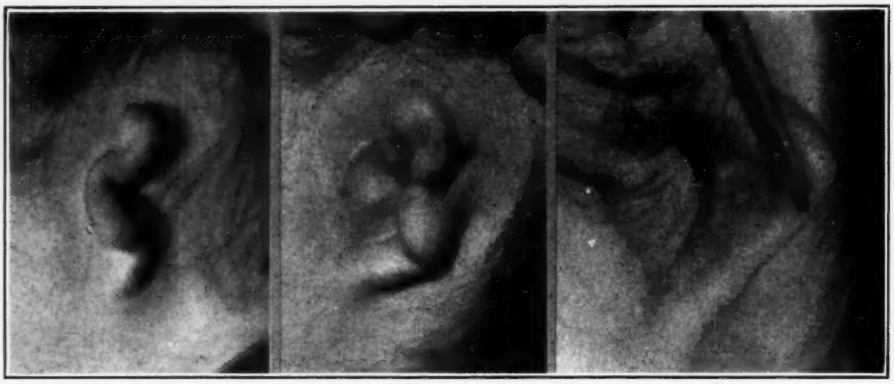
The patient had been thrown from a motorcar onto the road, and his left ear torn from his head and left attached to a flap of skin on his cheek. It was hastily replaced as a roadside emergency and when healed it was discovered that the external auditory meatus was completely stenosed and the ear half an inch lower on the left side than on the right. The patient was, of course, completely deaf on that side. End-to-end anastomosis of the severed meatus was out of the question, because it had been torn off flush with the bone (Fig. 16). In this instance I turned back a flap, exposed the bony meatus, and after careful dissection discovered the inner end of the meatus about a quarter of an inch from the tympanic membrane.

A large cavity was made communicating with the central remains of the meatus and this filled with a block of gutta percha covered with thin skin. The skin graft was practically in contact with the tympanic membrane. The whole ear was sutured back over the mold, and a small drain left in a dependent position. The mold remained in situ for three months, during which time there was a considerable amount of discharge from the drain hole, but nothing else to indicate any serious inflammatory reaction. At the end of three months, I again turned the ear forward and found a perfectly soft, completely skin-lined cavity on the inner side of which was



A. *B.* *C.*

Fig. 16.—*A*, Traumatic stenosis of external auditory meatus; *B*, separation of ear posteriorly, removal of fibrous tissue mass, isolation of inner end of meatus, and insertion of skin-covered mold into cavity; *C*, skin-lined cavity connected to external ear three months later after removal of mold.



A. *B.* *C.*

Fig. 17.—*A*, Congenital absence of external auditory meatus; *B* and *C*, middle ear has been opened through mastoid and skin grafted; patent meatus shown.

the patent bony meatus and the tympanic membrane. It was then a comparatively simple matter to anastomose the outer side of the cavity to the outer end of the meatus, and to replace the ear in its normal position. The result has been completely satisfactory, and the hearing is now restored.

An occasional use for cavity grafting in the ear is in the condition of congenital absence of the external ear and external auditory meatus, where there is strong evidence, x-ray and otherwise, that the middle

ear, ossicles, and cochlea remain. In several instances of this condition, I have opened the mastoid, determined the presence of ossicles, and skin grafted the bony canal leading to the middle ear (Fig. 17). Otoplasty can then be performed round the meatus so formed. Although the number of cases in which hearing is improved is very small, I believe the attempt is justifiable.

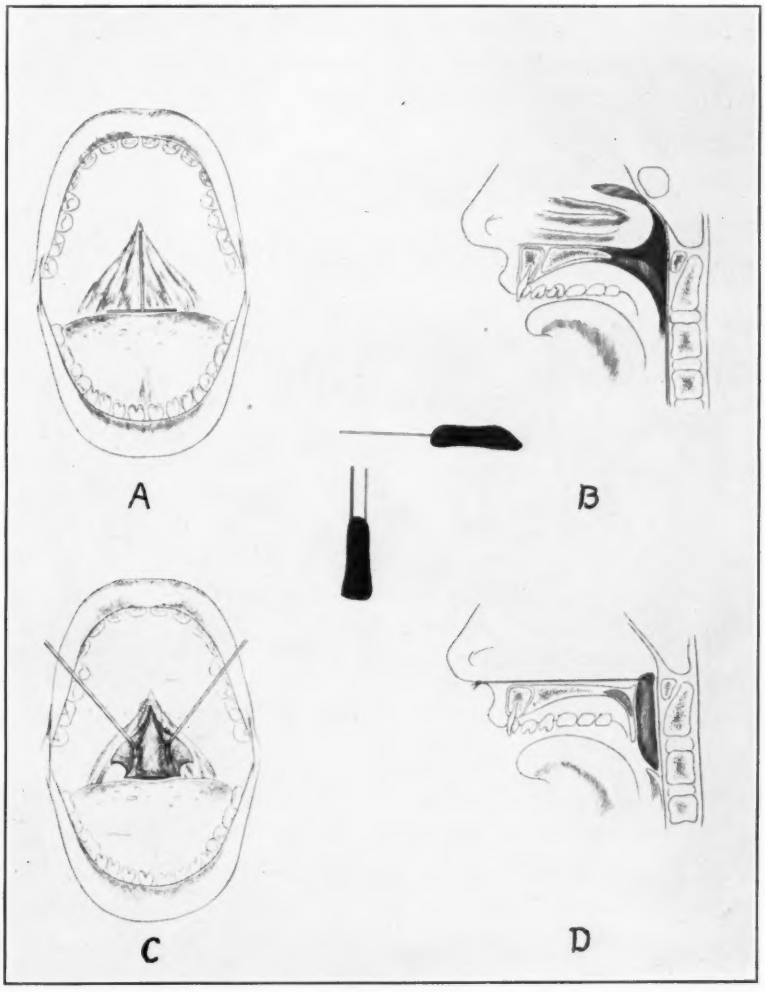


Fig. 18.—*A* and *B*, Syphilitic stenosis of palate, showing complete and extensive attachment of soft palate to posterior pharyngeal wall. *C* and *D*, after separation of the palate, a stent mold is introduced, covered with thin razor graft, and maintained in place for two months by a silk thread.

THE POSTERIOR PHARYNGEAL SPACE

One of the most difficult conditions which one can be called upon to treat is complete obliteration of the oronasal space due to specific disease, or to a disastrous tonsillectomy. The extent of the stenosis is usually so widespread that manipulation of flaps fails to create a passage from the pharynx to the nose. The complete absence of nasal

drainage produces an indescribably septic condition of all the accessory sinuses and makes the condition of these patients miserable in the extreme.

I have found that after boring a hole between the adherent palate and the posterior pharyngeal wall from the pharynx into the nasal cavity, and inlaying skin on a mold retained by double silk threads tied round the columella and retained in place for at least two or three months, an excellent passage can be made (Figs. 18 and 19). Drainage of the nasal cavity and sinuses is effected with remarkable improvement in the general health of the patient.

THE URETHRA

Those who undertake the responsibility for the radical cure of hypospadias know that the condition is one of the most difficult of all surgical operations to bring to a successful conclusion. The difficulty

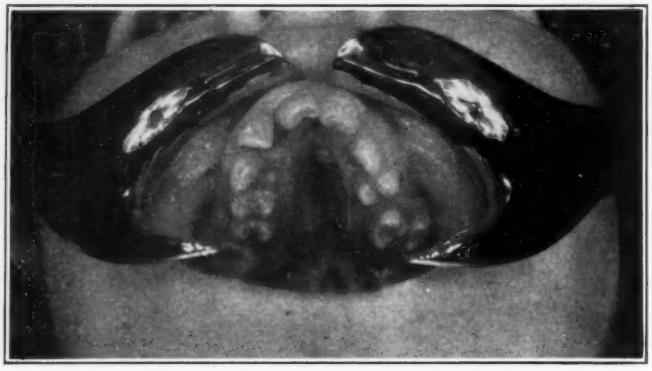


Fig. 19.—Complete specific stenosis of posterior pharyngeal space cured by an inlay graft.

lies not so much in technical performance as in obtaining healing *per priman intentionem* by methods which necessarily violate all the principles of plastic repair. Most operations attempt to reconstruct an epithelial lined urethra at the expense of the skin of an already attenuated organ which is little able to afford such a loss. The result is only too frequently undesirable tension of flaps, superimposed suture lines, indifferent blood supply to skin edges, and consequent breaking down of the new urethra in part if not completely. My own experience in the primary repair of hypospadias is not unique in that I have been exceedingly dissatisfied with my results and with the methods employed to gain them. Particularly is this so in adult males with hypospadias in whom so many unsuccessful operations in infancy have been performed that failure with any form of flap operation is a foregone conclusion. Consideration of this particular type of adult patient has led me to experiment with the principle of the epithelial inlay with,

I believe, more encouraging results. In the past, attempts have undoubtedly been made to reconstruct a urethra by means of Thiersch grafting, but a close examination of the reported cases convinces me that those who attempted this method were wrong in principle, in that intermittent dilatation was considered sufficient to maintain the patency of the skin-lined tube, whereas, as in every other type of epithelial

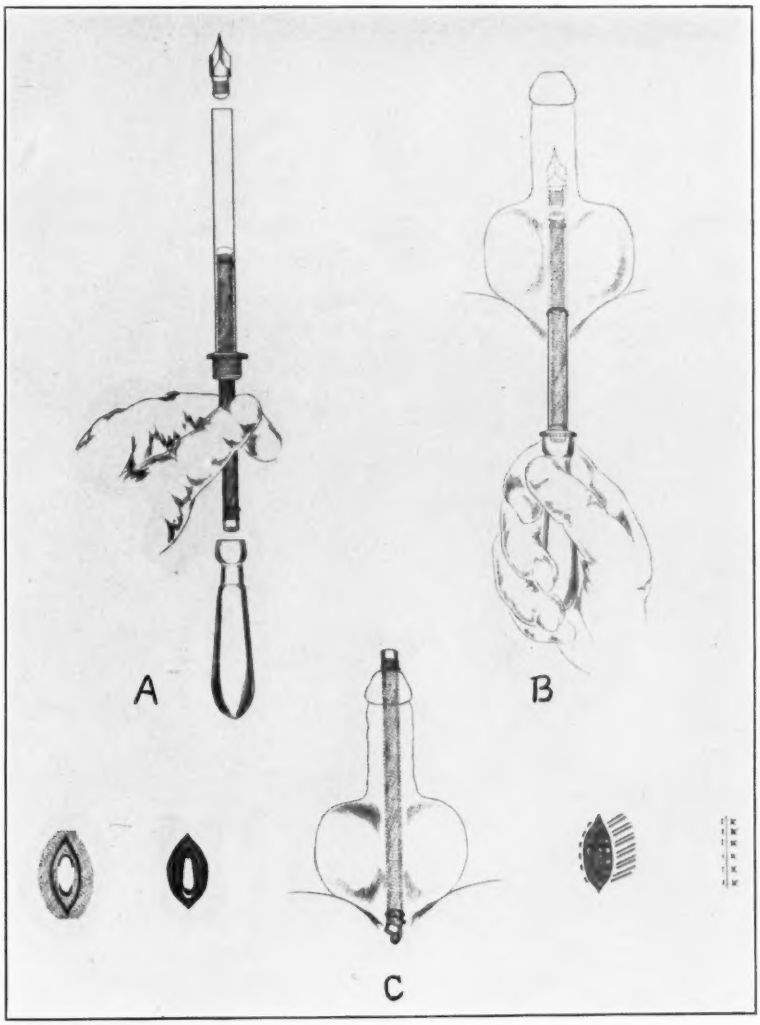


Fig. 20.—*A*, Author's skin graft introducer for hypospadias; *B*, method of insertion; *C*, inlay graft in position. Insert shows method of anastomosis of new urethra to hypospadiac meatus.

inlay, continuous and prolonged dilatation is necessary from the first until the contractile phase common to all free skin grafts is over.

Utilizing the inlay principle, two methods are available: (a) The open method by which at one operation the penis is split ventrally, the remains of the corpus spongiosum removed, and an inlay graft

spread on a catheter of a large size placed in a groove along the whole length of the lengthened penis, being brought out at the glans anteriorly and at the perineum posteriorly. The graft is well oversewn, and the entire organ bandaged in a mastisol case to obtain the neces-

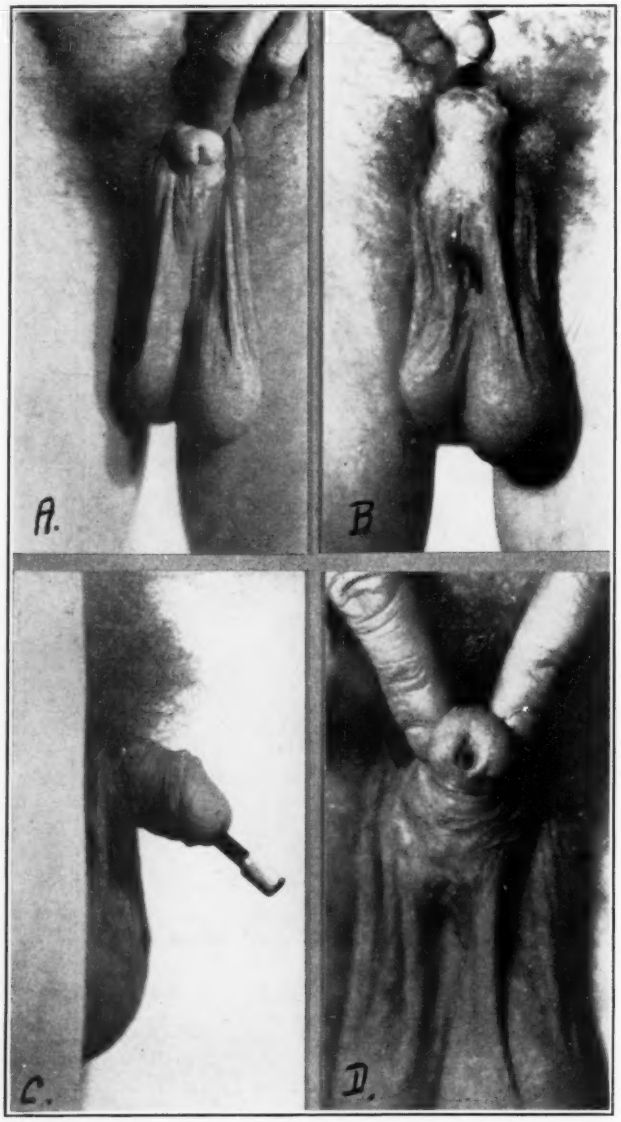


Fig. 21.—*A*, Primary adult scrotal hypospadias; *B*, epithelial inlay after Edmunds' straightening operation; catheter No. 11 in place for five months; *C*, showing correction of ventral curve; *D*, final result after end-to-end anastomosis; note normal appearance of meatus.

sary pressure. This method is being developed by Sir Harold Gillies. (b) The closed method, which is used after straightening has been accomplished at a preliminary operation by Edmunds' method. The difficulty of applying this method is the mechanical one of passing a

skin-covered catheter along a tunnel two or three inches in length, without rucking the skin off the catheter and so leaving raw areas ungrafted. I, therefore, constructed an introducer which obviates this difficulty very simply. The instrument resembles a suprapubic trocar except that the handle and the cutting point can be unscrewed, leaving a smooth barrel five inches long, open at both ends, which will just admit a piece of No. 11 gum elastic (Fig. 20). The method is as follows:

A thin Thiersch graft is cut from the inner side of the arm and carefully applied raw surface outward, like a piece of cigarette paper, to the section of catheter, which is then carefully placed in the barrel of the instrument, and the cutting point and handle screwed on. A small stab incision is made just distal to the orifice of the perineal or penile meatus, and another at the dimple usually present at the tip of the glans. With the patient in the lithotomy position, the trocar introducer is then thrust along the penis subcutaneously from the posterior stab incision until the point emerges at the tip of the penis. It passes between the ventral penile skin and the corpora cavernosa. This maneuver, while not easy, can be facilitated by the introduction of a long pair of slender scissors with Mayo points, in order to divide any fibrous bands which obstruct the passage of the instrument. The cutting point of the introducer is then unscrewed and the end of the skin-covered catheter gripped firmly with a pair of forceps. The barrel of the instrument is then carefully withdrawn and the skin-lined urethra rinsed through with saline or half-strength Eusol. A fresh piece of catheter is immediately placed in the urethra. Sitz baths and syringing should be persevered with daily at the same time until healing is complete. At no time during the next three to four months should the new urethra be left without its catheter in place, and the patient himself must be warned against this. At the end of that time, the contractile phase is over, and the catheter may be safely left out. In six months, end-to-end anastomosis of the posterior end of the new urethra and the perineal fistula is performed over a short piece of catheter (Fig. 21).

The result of this operation is the most normal looking urethra which can be obtained by any method yet described. This is particularly true of the meatus, which can thus be made to appear at its usual position in the glans, something which no flap operation can accomplish.

HOMOGRAFTING OF SKIN: WITH REPORT OF SUCCESS IN IDENTICAL TWINS

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IT HAS been generally found that skin transplanted from one individual to another does not survive permanently. Many reports of success originate from occasional observers but, when the patients are examined, one cannot be sure that any graft is present. The usual course in these patients is that, following a possible "take" of the graft, there has been survival for two weeks, but total absorption of the graft by the end of the third week. This has been followed by a period of granulation, and then spontaneous epithelization has occurred, perhaps somewhat rapidly—and in some instances it has apparently been mistaken for transplanted skin. A very occasional homograft might survive, but the chance is so remote that, on an active surgical service where many skin grafts are done, the method could not in any manner be relied upon.

Suggestions have been made to try to insure permanence of these grafts, the best known of which is that the donor and recipient should be of the same blood group, but there is no measurable value of this selection of donor skin either in the "take" of the graft or its survival. Other methods have been something like desensitizations—injection of the recipient's blood around the graft site on the donor, delaying the graft and exposing it to the recipient's serum, and doing preliminary transplants to try to accustom the donor to the presence of foreign skin. The method of Stone in the culture of donor parathyroids in the recipient's serum has so far not been reported successful in working with skin, but may prove to be possible, at least, for the single element of epithelial cells. The successful solution of this problem would be one of the major advances in reconstructive surgery, but for the present, the patient's own available skin must be depended upon. By using thick split skin grafts (thick Ollier-Thiersch grafts) in all possible repairs, one can usually find sufficient quantity of donor skin and by careful removal of the grafts, the same donor site may be used as many as three to four times.

In two instances, I have used homografts from the mother to tide over very serious periods in the care of patients whose conditions might otherwise have proved fatal, and, in both instances, it was thought that the

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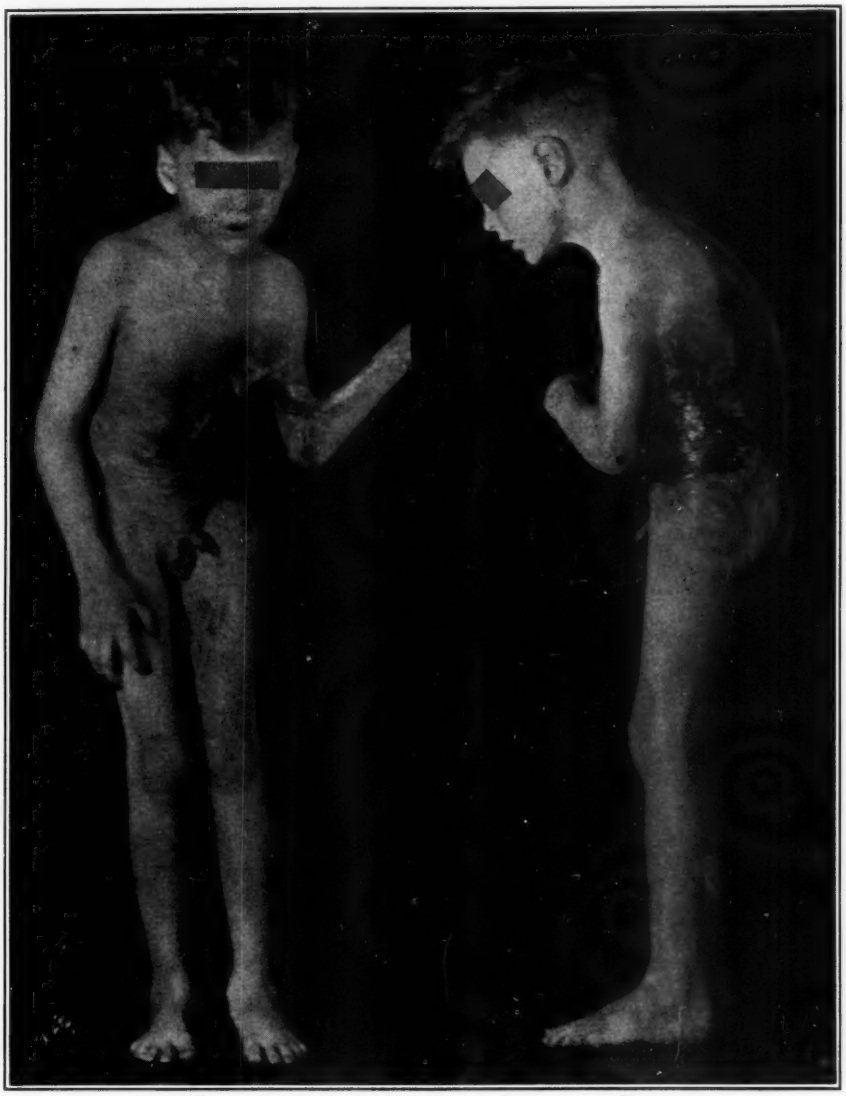
two weeks' respite that was afforded the patients from the open wound was the turning point in their outcome.

The boy shown in Fig. 1 had a deep burn which extended very close to the peritoneum. His reaction to any type of treatment was extremely bad, and from the irritation and itching around the wound, he



A. *B.*

Fig. 1, *A* and *B*.—Condition of patient at time homografts from mother were applied.

developed an abnormal desire to rub and scratch the area. His general health went down so badly that it was feared he would not survive. Then, as a last resort, to provide a covering for the wound, thick split homografts from the mother were applied to the entire area to remain in place for as long as they might last. There was immediate local and

general improvement, the grafts took almost perfectly, and for two weeks, while the grafts survived, the child was comfortable. By the end of the third week, the grafts were completely absorbed, but the wound was much improved, and the patient was comfortable. There was then apparently a real stimulus to his own spontaneous epithelization, and

2. 3.

Fig. 2.—After homografts had been in place two weeks and then had been completely absorbed, there was fairly rapid spontaneous healing with the deformity shown here.

Fig. 3.—Result after release of deformity and removal of scar, and application of thick split grafts from the thigh to the axilla, arm, chest, and abdomen.

the area rapidly covered over, as shown in Fig. 2. Release of scar tissue and resurfacing with thick split grafts could then be done, so that the final result, as shown in Fig. 3, was obtained.

A second patient, who had even a more refractory course and worse reaction to pain, was treated in the same manner except that only one-third of her wound was covered, because it was a complete circular loss on the thigh, and it was not thought best to sacrifice this much donor skin (Fig. 4). Fig. 5 shows a complete "take" of thick split grafts

Fig. 4.—Shows very dirty wound from complete, circular full thickness loss of skin. Patient, on one occasion, had been taken from hospital by parents because of extremely bad reaction to treatment.

Fig. 5.—Photograph made at time of first dressing, four days after operation, showing complete "take" of thick split grafts which had been taken from patient's mother at time of operation. These grafts persisted about two weeks.

from the mother after four days; following this, there was marked alleviation of the patient's pain reaction, and the wound and general condition steadily improved. These grafts were entirely gone in two and one-half weeks, but the greatly improved appearance of the wound after

Fig. 6.—Shows same leg twenty-two days later with complete solution of the homografts, but much improvement in appearance, with beginning healing.

Fig. 7.—Final restoration with thick split grafts from the opposite thigh.

three weeks is shown in Fig. 6; the granulations are firm, and the epithelial edge is spreading. The islands of epithelium are from implantation grafts that had been put in before the homografts were applied, but which had not given evidence of enlarging. The final result, as shown in Fig. 7, was obtained in two operations with thick split grafts from the opposite thigh.

For several years I hoped to have the opportunity of using homografts from an identical twin, but never encountered a burned patient with a twin, and then, through the courtesy of Dr. O. J. Wilhelmi, I contacted

Fig. 8.—Complete and permanent survival of full thickness grafts transferred from the arm of one identical twin to that of the other. The darkened edge is a moderate keloid formation.

identical twins who kindly donated their time and small areas of their skin for cross transplantation. Accordingly, I transferred full thickness skin grafts from the arm of one twin to that of the other and obtained primary healing in both with complete and permanent survival of both grafts. Fig. 8 shows the grafts after five months; they have now been in place three years. Padgett also has noted the survival of homografts in identical twins.

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A COMPARATIVE STUDY OF THE PHYSIOLOGIC ACTIVITY OF COBEFRIN AND EPINEPHRINE*

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SINCE 1894, when Oliver and Schäfer found that the extract obtained from suprarenal glands produced a rise in blood pressure when injected intravenously into animals, much interest and work has been devoted to this pressor substance, as well as to other pressor compounds. Abel is said to have isolated the first hormone from these glands; however, Takamine and von Fürth have contributed much to the knowledge of this new substance which was called "epinephrine" by Abel, "adrenalin" by Takamine, and "suprarenin" by von Fürth. Shortly after the discovery of the hormones, Jowett demonstrated that its chemical identity was (3, 4-dihydroxyphenyl)-1-methylamino-2-ethanol. Barger and Dale were among the earliest investigators to study its activity when it was modified slightly by various substitutions. In 1923, Chen observed that a preparation obtained from the plant ma huang also had a distinct pressor activity, and he noted that its action was not unlike that of epinephrine. The well-known work of Chen and Schmidt hardly needs further comment. The pressor substance, ephedrine, which they isolated from plants of the genus Ephedra has one advantage over epinephrine, namely, that it is active when administered by mouth.

Hartung, in a classic review of epinephrine and allied compounds, has demonstrated that an isomer of epinephrine, which possesses the same pressor activity as epinephrine, is much less toxic than epinephrine and is active when administered orally. This substance, which has been identified for some time, was known formerly as norhomoepinephrine, or 3, 4-dihydroxphenylpropanolamine. It is now known as cobefrin. A comparison of the structural formulas of epinephrine, ephedrine, and cobefrin is shown in Fig. 1.

Hartung and Munch found that when 3, 4-dihydroxphenylpropanolamine was injected intravenously into rabbits, its toxicity was less than a hundredth as great as that of epinephrine, and that qualita-

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tively its effect on the circulatory system was indistinguishable from that of epinephrine; however, it is less potent in its action, being a twelfth as active as levorotatory epinephrine. They attributed the activity of the substance, when given by mouth, to the shifting of the methyl group from the nitrogen atom to extend the side chain by two or three carbon atoms. The levorotatory form is two or three times more active than the dextrorotatory form, and it is 60 to 65 per cent as active as levorotatory epinephrine. The oral activity of ephedrine, likewise, has been shown to be the result of the presence of a third carbon atom in the aliphatic side chain. Barger and Dale showed that the introduction of two hydroxyl groups into the aromatic nucleus, one in para and the other in meta position, resulted in maximal pressor activity.

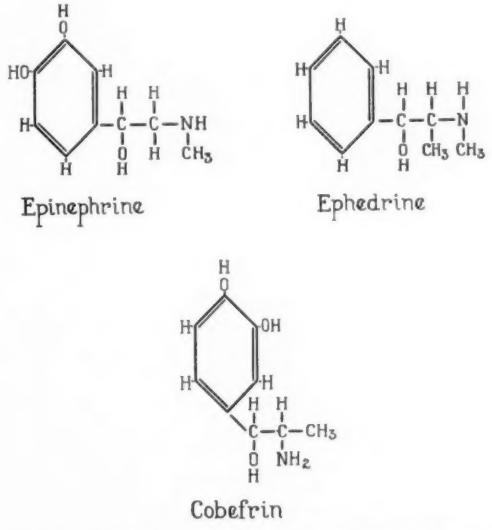

Fig. 1.—Chemical structures of epinephrine, ephedrine, and cobefrin.

Cobefrin has been used clinically in combination with a solution of procaine to produce local anesthesia, by several German workers. Hirsch has employed this combination for tonsillectomy and various other operative procedures on the eyes, ears, nose, and throat. He commented that the advantage in the use of cobefrin is that it does not cause a sudden fall in blood pressure through a vagal reflex. This, he asserted, is responsible for the lack of untoward subjective symptoms such as tremor, dizziness, palpitation, and minor syncopal reactions. Furthermore, he said that cobefrin may be given to individuals who have an idiosyncrasy to epinephrine, without fear of any untoward symptoms or reaction. Hermann and Ruthsatz confirmed the observations of Hirsch and also made similar recommendations as to the usefulness of this new agent.

Cobefrin, as it is supplied commercially, is said to be seven and a half times less toxic than epinephrine when injected into albino rats, and its average pressor action is a fourth to a fifth that of epinephrine. Thus, a 0.5 per cent solution of cobefrin should be equal in strength to a 0.1 per cent solution of epinephrine.

Because of the assertions that have been made relative to the activity of cobefrin, studies were carried out in order to compare its activity with that of epinephrine. These studies included observations of: (1) the effect of the drugs on the blood pressure; (2) the action of the drugs on the isolated heart of the rabbit; (3) the action of the drugs on the isolated uterus of the virgin guinea pig; (4) the action of the drugs on the lungs; (5) the site of destruction of the drugs; and (6) the hyperglycogenic properties of the drugs. The effect of the drugs on the blood pressure was observed while the animals were under general anesthesia (sodium amytal or ether), and before and after the animals had been subjected to hepatectomy.

EFFECT OF COBEFRIN AND EPINEPHRINE ON BLOOD PRESSURE

While the animal was under general anesthesia.—Dogs were anesthetized with sodium amytal (sodium isoamylethylbarbiturate) or ether, and the blood pressure in the carotid or femoral arteries was recorded. A 0.1 per cent solution of epinephrine and a 0.5 per cent solution of cobefrin were used for comparison of pressor activity. A uniform dosage (0.01 c.c. for each kg. of body weight) of each substance was given intravenously.

It was found that the resulting increase in the blood pressure is maintained for a longer period of time with cobefrin than it is with epinephrine (Fig. 2). In the series of experiments with cobefrin, it was most noteworthy that the constantly occurring vagal slowing, which accompanies the vasopressor activity of crude epinephrine, was eliminated. We were not able to reproduce a typical response of the blood pressure curve to the administration of epinephrine by using the commercial preparation at hand. Similar doses of highly purified epinephrine* were injected intravenously, but the resulting increase in the blood pressure was practically identical with that which followed the administration of commercial epinephrine; no vagal inhibition was noted. Its action differed from that of cobefrin in only one respect, namely, that the duration of the pressor effect was shorter. It was suggested that crude epinephrine made from whole suprarenal glands of beeves, that is, epinephrine which was made from the cortical and medullary portions of the glands, possibly might produce a different response; therefore, epinephrine was made according to the original technic of Abel. The administration of this preparation elicited a pressor response with

*Obtained from E. C. Kendall, the Mayo Foundation, Rochester, Minn.

a characteristic notch in the curve, vagal slowing, and a slight secondary fall in blood pressure. This was the first record of the blood pressure in eight experiments which in any measure simulated the classic response to the administration of epinephrine (Fig. 3). The responses obtained when commercial epinephrine was used closely resembled the effect that is produced on a vagotomized animal. It seemed plausible, in view of these findings, that there was some substance present

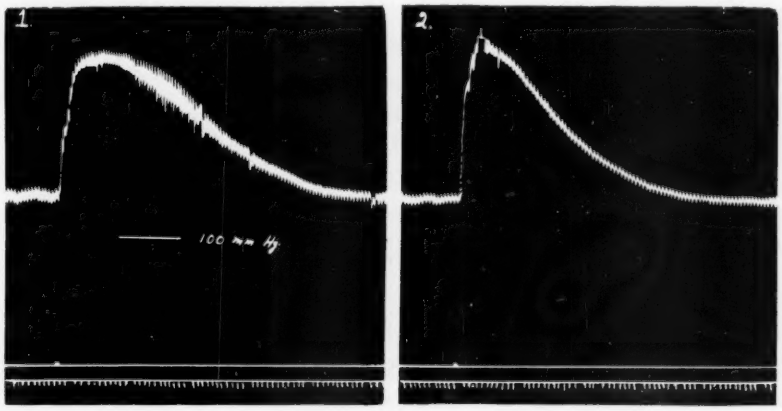

Fig. 2.—The effect on the blood pressure of an intravenous injection of (1) 0.35 mg. of cobefrin and (2) 0.07 mg. of epinephrine; weight of the dog was 7 kg.; the duration of the pressor effect of cobefrin is slightly longer than that of epinephrine.

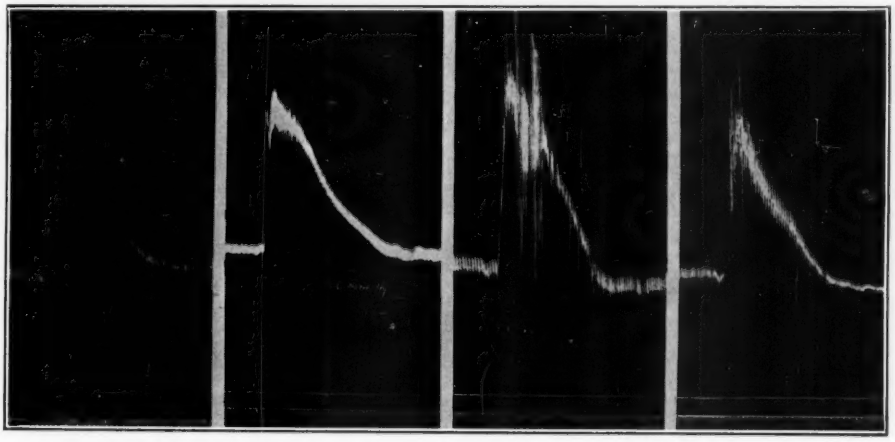

Fig. 3.—The effect on the blood pressure of an intravenous injection of (1) 0.12 mg. of highly purified epinephrine, (2) 0.12 mg. of commercial epinephrine, (3) 0.13 mg. of crude epinephrine (estimated dose), and (4) a mixture of 0.065 mg. of cobefrin and 0.065 mg. of commercial epinephrine; weight of the dog in (1) and (2) was 12 kg. and in (3) and (4), 23 kg.; one may note the vagal reflex and a decrease in the blood pressure in (3).

in the crude epinephrine which is absent in the preparation now supplied commercially. In several instances we found that even after vagotomy the heart showed evidences of vagal-like slowing when crude epinephrine was injected intravenously. This, at least, suggested the possibility of local activity on the heart and not a reflex inhibitory mechanism.

Numerous attempts to isolate from the crude epinephrine a principle which contained no epinephrine or other pressor substance, but which produced cardiac slowing, were unsuccessful. Another observation worthy of note is the not infrequent occurrence of evidence of cardiac slowing, vagal or otherwise, when cobefrin is given to an animal following a previous injection of commercial epinephrine. It was impossible to explain this phenomenon. Interesting also is the fact that administration of equal mixtures of commercial epinephrine and cobefrin produce a blood pressure curve which is a combination of the curves produced by each substance separately. Cortical extract (cortin) given intravenously (1 c.c. to a dog weighing 16 kg.) did not produce any increase in blood pressure on several occasions.

While the animal was under local anesthesia.—A 2 per cent solution of pantocain was used to infiltrate the tissues around the femoral artery. The blood pressure then was recorded in the usual manner by

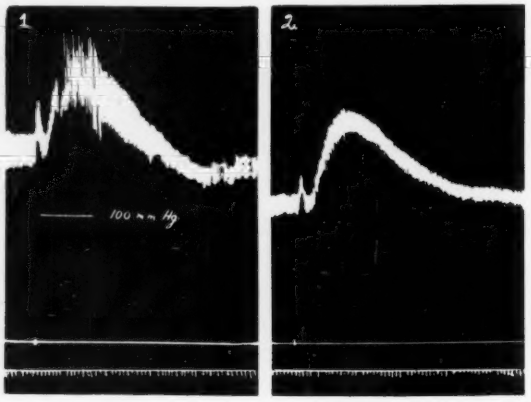

Fig. 4.—The effect on the blood pressure of an intravenous injection of 1.2 mg. of cobefrin (1) previous to hepatectomy, and (2) after hepatectomy; weight of the dog was 24.7 kg.

means of cannulation. Little difference was apparent between the pressor effects under general anesthesia and those under local anesthesia, except that the increase in blood pressure which followed the administration of epinephrine or cobefrin was not as marked under local anesthesia as it was under general anesthesia. Cobefrin again showed a slightly more prolonged action.

Before and after hepatectomy.—This experiment was performed on an animal which weighed 24 kg., after the first two steps in the technic of hepatectomy had been performed. The dog was anesthetized with ether, and the record of the blood pressure was taken by means of a cannula in the femoral artery. At the same time, 1.2 mg. of cobefrin was given intravenously. The animal was then operated on again, and the liver was removed. Shortly after hepatectomy, the same dosage of cobefrin was repeated, and another tracing was taken of the response of the blood pressure. There is little significant difference in

the two kymographic records of the blood pressures, save that the record obtained before hepatectomy shows a little more evidence of vagal inhibition with slowing of the heart rate than does the record obtained after hepatectomy. The duration of the pressor effects was practically the same in both instances (Fig. 4).

When cobefrin and epinephrine were given orally while the animal was under general anesthesia.—The animals were anesthetized with sodium amytal, and the blood pressure in the femoral arteries was taken in the usual manner. Cobefrin (2 mg. for each kg. of body weight) was mixed with physiologic saline solution and placed in the stomach by means of a small rubber tube. A definite pressor response was obtained in one and a half minutes. The blood pressure increased gradually and subsided slowly after having remained slightly elevated for almost thirty minutes. A similar dose of epinephrine did not produce any effect on the blood pressure (Fig. 5). Herein lies one distinct difference between epinephrine and cobefrin; cobefrin is active when administered orally, while epinephrine is not.

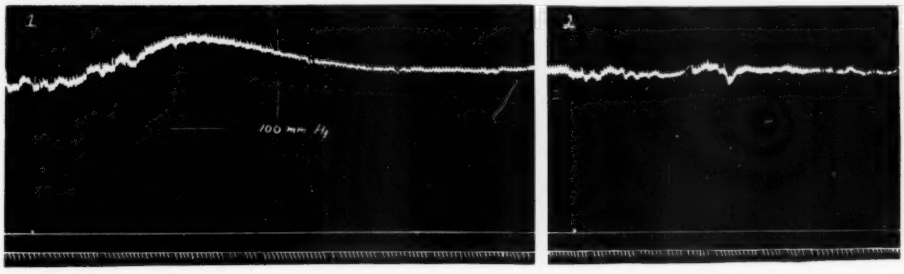

Fig. 5.—The effect on the blood pressure of the oral administration of (1) 2 mg. of cobefrin, and (2) 2 mg. of epinephrine; weight of the dog was 8 kg.; no increase in the blood pressure was produced by epinephrine.

ACTION OF COBEFRIN AND EPINEPHRINE ON THE ISOLATED HEART OF THE RABBIT

The heart was perfused at a temperature of 37.5° C., according to the method of Locke and Rosenheim. The addition of 0.25 mg. of cobefrin to the perfusion fluid (500 c.c.) caused a rapid increase in the rate of the heart. Within three minutes after the addition of the cobefrin, the rate of the heart had increased from 136 beats a minute to 148 beats a minute, and within seven minutes, the rate was 183 beats a minute. Associated with this tachycardia, there was a slight decrease in perfusion flow from 36 c.c. a minute to 29 c.c. a minute. The increase in the rate of the heart continued for an hour and a half before the rate returned to the control figures. A second injection of cobefrin was given an hour and forty-five minutes after the first. This produced similar results (Table I).

A dose of 0.05 mg. of epinephrine, which was also added to the perfusion fluid, produced a definite tachycardia, but no change in per-

TABLE I

ACTION OF COBEFRIN ON THE ISOLATED RABBIT HEART

TIME	HEART			TIME	HEART		
	RATE PER MINUTE	OUTPUT, C.C.			RATE PER MINUTE	OUTPUT, C.C.	
		PER MINUTE	IN FIVE MINUTES			PER MINUTE	IN FIVE MINUTES
9:27 A.M.	145			11:06			120
9:29	140			11:09	146		
9:30			172	11:12			115
9:34	138			11:14	148		
9:36	134		190	11:18			110
9:40	137		188	11:23	158		
9:45	130	36.4		11:27	154		
9:47	144		188	11:31	148		99
9:50	142			11:41	130		70
9:53	140		180	11:50	134		70
9:57	138			11:52	134		
10:00	138			11:55	132		68
10:02	138		178	12:00 M.			
10:14	136			12:01 P.M.	128		
10:15*				12:04	134		60
10:16	137			12:07	142		
10:18	148			12:09	153	14.5	72
10:22	183		170	12:10	166		
10:24	183			12:13	157		
10:25			168	12:16	167		68
10:27	174			12:20	158		
10:29	172			12:23	146		
10:30	168			12:26	149		60
10:31			162	12:28	142		
10:34	174			12:30	144		
10:35	180			1:50	136		56
10:36	178			1:55	132		
10:38			148	1:57†			
10:41	170			1:59	128		
10:42	164			2:00	160		58
10:44			140	2:02	162		
10:47	162	26.0		2:03	170	15.7	55
10:50	158			2:05	164		
10:51			130	2:08	160		56
10:54	156			2:10	155		
10:55	154			2:12	150		54
10:56	152		128	2:20	145		
11:00	148			2:25	140		

*0.25 mg. cobefrin added to the perfusion fluid.
†0.05 mg. epinephrine added to the perfusion fluid.

fusion flow. The duration of the increase in the cardiac rate was shorter after the addition of epinephrine than it was after the addition of cobefrin. This may be attributed to fatigue, however, since the preparation had been operating for more than three and a half hours. When a fresh preparation is used epinephrine usually causes an increase in cardiac rate and perfusion flow.

ACTION OF COBEFRIN ON THE ISOLATED UTERUS OF THE VIRGIN GUINEA PIG

Since it is well established that epinephrine usually produces relaxation of isolated smooth muscle, cobefrin was studied for comparison. A small strip of the uterus of a guinea pig was perfused with an

oxygenated Ringer-Locke solution at a temperature of 37.5° C. The addition of 0.05 mg. of cobefrin to 50 c.c. of water in a water-bath which contained a rhythmically contracting uterus, produced practically immediate cessation of activity. This quiescent period usually lasted from five to eight minutes. In comparison, cobefrin is just as effective in producing this response as is epinephrine.

ACTION OF COBEFRIN ON THE LUNGS

Closely allied to the action of cobefrin on the smooth muscle of the uterus or intestine is the well-known action of epinephrine in alleviating bronchospasm which may be the result of an allergic condition or which may be produced experimentally with histamine. Several guinea pigs (average weight 0.5 kg.) were given 0.15 mg. of histamine intravenously; this produced severe bronchospasm in each animal. All of the animals in the control group died; of those that were given 0.1 c.c. of 1 to 1,000 solution of epinephrine, all but two survived. The technical difficulty in giving the solution of epinephrine intravenously accounted for delay in its administration and the resultant death of the two animals.

After producing bronchospasm in another group of animals with histamine, 0.5 c.c. of a 1 to 1,000 solution of cobefrin was given, and the bronchospasm was relieved in the same manner as it was by the administration of 0.1 c.c. of a 1 to 1,000 solution of epinephrine. Likewise, in this experiment, all of the control animals died, while there was only one death among those which had received cobefrin. The average duration of the bronchospasm following the administration of either epinephrine or cobefrin was four minutes, and then recovery occurred. The average length of time before death occurred in the animals which did not receive epinephrine or cobefrin was two and a half minutes.

Bronchospasm of guinea pigs that is produced by administration of histamine or by sensitization to foreign protein (2 per cent solution of egg white) could be relieved as efficiently with the intravenous administration of epinephrine as it could with intravenous administration of cobefrin. When either one is given intramuscularly or subcutaneously, however, the absorption is too slow to relieve the bronchospasm, and the animals die before the action of the drug takes place.

SITE OF DESTRUCTION OF EPINEPHRINE AND COBEFRIN IN THE BODY

Elliott, in 1905, said that the general capillary bed in the entire animal body serves as a site of elimination or destruction for epinephrine, with one exception, namely, that of the lungs. It is not possible to demonstrate by perfusion any loss of epinephrine in these

organs. In order to determine whether the lungs played any significant part in the elimination or inactivation of cobefrin, experiments with the Starling heart-lung preparation were carried out.

Heart-lung perfusion experiment.—Routine preparation of a dog weighing between 10 and 12 kg. was made under ether anesthesia, and 1.0 to 1.5 liters of blood obtained from healthy dogs were added to the venous reservoir of the perfusion apparatus. Fifteen mg. of cobefrin were introduced into the venous reservoir after a control sample of 5 c.c. of blood had been taken for analysis. On the addition of cobefrin, the cardiac rate was rapidly accelerated, and this acceleration was maintained for two to two and a half hours. Samples of blood were taken at varying intervals from the venous reservoir for three and a half hours. These were tested along with the control blood by determining the effect on the blood pressure of a small dog which weighed 6 to 8 kg. The test animals in all perfusion experiments were anesthetized with sodium amytal (50 mg. for each kg. of body weight). The results of

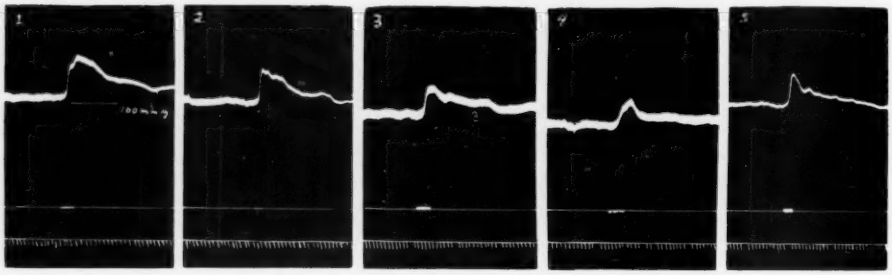

Fig. 6.—The effect on the blood pressure of successive injections of 5 c.c. of blood which contained approximately 0.01 mg. of cobefrin per c.c. previous to perfusion through the heart-lung-hindlimb preparation: (1) before perfusion, (2) after perthirty minutes, (3) after perfusion for one hour, (4) after perfusion for two hours, (5) after perfusion for three hours; there was no appreciable change in the response of the blood pressure after the blood had perfused for one, two, and three hours.

this test indicated that in several experiments practically none of the cobefrin had been destroyed or inactivated by the heart-lung perfusion (Fig. 6).

Since it has been demonstrated that the liver has the ability to inactivate, detoxify, and destroy many substances, among which are nicotine and strychnine,[12] we attempted to ascertain if hepatic tissue could change or affect the pressor properties of cobefrin. Markowitz and Mann, in their study on the destruction of epinephrine in the body, showed that it disappears in practically all of the tissues of the body, and that no organ or viscus is specific for its elimination.

Heart-lung-liver perfusion experiment.—A dog weighing 8 kg. was used for this experiment. One liter of blood was obtained from a healthy dog to augment the supply of blood in the venous reservoir. After routine preparation of the animal, cobefrin in a concentration of 0.015 mg. for approximately each c.c. of circulating blood was

added to the venous reservoir. The blood flow from the liver was measured periodically during the experiment to determine the variation in quantity during and following the activity of cobefrin. The blood pressure and pulse rate were likewise recorded at intervals. Samples of the perfused blood (10 c.c.) were taken intermittently during the course of the experiment for testing. A dog which weighed 5.5 kg. was used for the test. The data in this experiment are correlated in Table II.

Testing of specimens of blood.—Specimens of blood which had perfused through the heart-lung-liver preparation for one, two, and three hours gave practically identical pressor responses in the test animal, which indicated that very little, if any, of the cobefrin had been destroyed after the first hour of perfusion. Other specimens, which were taken twelve, twenty-three, and thirty-four minutes after the addition of cobefrin, showed a progressive decrease in the amount of pressor response, but the maximal destruction of the drug occurred within an hour, and subsequent specimens failed to indicate any further progression in its elimination (Fig. 7).

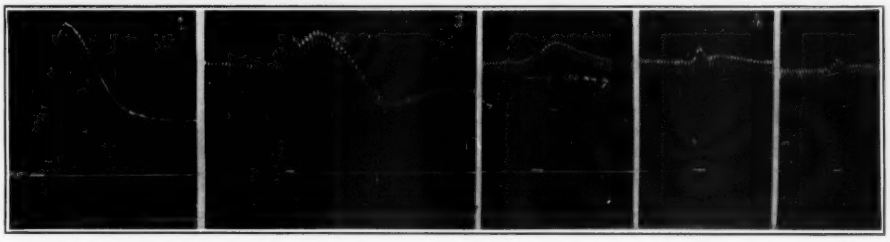

Fig. 7.—The effect on the blood pressure of successive injections of 10 c.c. of blood which contained approximately 0.015 mg. of cobefrin per c.c. previous to perfusion through the heart-lung-liver preparation; (1) before perfusion, (2) after perfusion for twenty-three minutes, (3) after perfusion for thirty-four minutes, (4) after perfusion for one hour, (5) after perfusion for three hours.

There is considerable reduction in the blood flow from the liver after the addition of cobefrin to the perfusion fluid; however, the duration of the constriction is usually not more than a fourth to a fifth of that seen in the heart-lung-hindlimb perfusion experiment which will be described next. It was the rule that, within three to five minutes after the introduction of cobefrin into the heart-lung-liver preparation, the return blood flow from the liver was reduced 80 per cent from control figures. This diminished return of blood from the liver endured for approximately twelve minutes.

From the results of the heart-lung-liver perfusion experiments, it was not possible to determine whether or not the liver was specific for the elimination of cobefrin. In order to ascertain whether any large capillary bed in the body would produce the same responses as those obtained with the heart-lung-liver preparation, the hind limbs were used in circuit with the heart-lung preparation.

TABLE II

HEART-LUNG-LIVER PERFUSION EXPERIMENT

TIME	BLOOD FLOW FROM LIVER, C.C. PER MINUTE	PULSE RATE, PER MINUTE	SYSTOLIC BLOOD PRESSURE, MM. OF MERCURY	REMARKS
10:20 A.M.			140	Control
10:24	175	140	140	
10:27	195	124	130	
10:29	215	126	130	
10:31	218	126	120	
10:33	220	126	120	
10:35	225	126	120	
10:42	225	128	120	15 mg. cobefrin added
10:45	125	190	118	Marked reduction in flow of blood from liver and increase in rate of heart
10:47	100	190	116	Blood pressure falling
10:50	100	190	115	
10:54	120	190	115	Blood flow from liver increasing
10:58	125	190	115	
11:01	140	188	115	Steady increase in blood flow from liver
11:04	150	188	115	
11:08	155	186	110	Decrease in rate of heart
11:12	185	180	110	
11:15	210	180	110	
11:19	240	180	110	
11:23	260	180	110	
11:25	280	180	100	Gradual decrease in blood pressure
11:28	300	180	100	
11:32	325	180	100	
11:34	350	180	105	
11:42	350	180	100	
11:48	400	180	75	Marked increase in blood flow from liver
11:53	380	182	70	
12:00 M.	345	182	70	Gradual decrease in blood flow from liver
12:04 P.M.	350	190	65	Increase in rate of heart
12:06	348	190	70	
12:08	335	190	72	
12:10	325	180	72	Cardiac rate decreasing
12:18	310		70	
12:28	305	170		
12:30	280		70	
12:35	280	170	70	
12:38	285		70	
12:42	280		70	
12:45	275			
12:47	260	140	60	
1:00	250	136	58	
1:12	215	134	60	
1:16	215	134	60	
1:27	205	130	58	

Heart-lung-hindlimb perfusion experiment.—The routine heart-lung preparation was made. In another animal, which weighed approximately 4.5 kg. and was under amytal anesthesia (50 mg. for each kg. of body weight) the abdominal aorta and inferior vena cava were

isolated, and ligatures were put in place in readiness for insertion of a cannula. The aorta was cannulated and received blood from the arterial side of the heart-lung preparation, and a similar insertion of a cannula into the inferior vena cava permitted the return of the blood to the venous reservoir.

Following these procedures, the limbs were rapidly isolated from the animal, and hemostasis was effected by ligatures. When the preparation was in equilibrium, cobefrin in a concentration of approximately 0.015 mg. for each c.c. of circulating blood was added to the arterial side of the circuit, the total dose being 15 mg. There was immediate cardiac acceleration, but within three minutes after the injection, the return flow from the hind limbs was reduced to one drop each second. This extreme vasoconstriction which was induced by cobefrin prevented perfusion of the limbs to any reasonable degree, and for almost an hour the blood was shunted into the venous reservoir while the preparation operated on a straight heart-lung per-

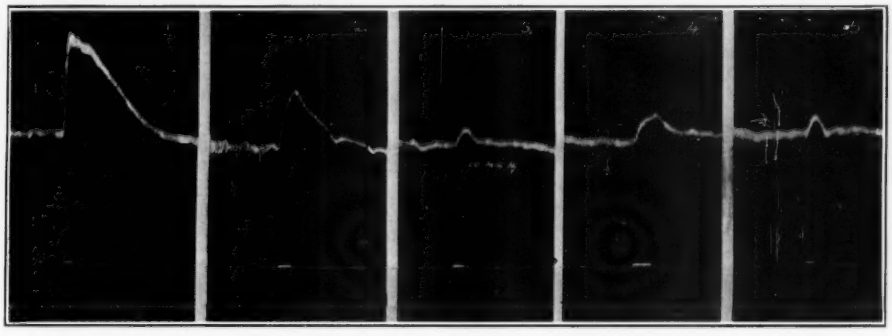

Fig. 8.—The effect on the blood pressure of successive injections of 10 c.c. of blood which contained approximately 0.015 mg. of cobefrin per c.c. previous to perfusion through the heart-lung-hindlimb preparation: (1) before perfusion, (2) after perfusion for twenty-five minutes, (3) after perfusion for forty-five minutes, (4) after perfusion for two hours, (5) after perfusion for three hours.

fusion (Table III). At the end of an hour the constriction became less and the venous flow from the limbs gradually increased. In comparison with the constriction noted in the liver perfusion, the hind limbs were constricted an hour longer. According to the same procedure in previous experiments, specimens of blood (10 c.c.) were taken from the venous reservoir and were tested on a dog weighing 8 kg., by noting the effect on the blood pressure (Fig. 8).

The pressor effect of a three-hour specimen of blood from the venous reservoir showed a slight increase in the blood pressure which was moderately sustained. A specimen of blood that had perfused for two hours gave a definite pressor response very similar to that of the three-hour sample. The injection of blood that had perfused for twenty-five minutes produced a marked increase in blood pressure, and the duration of the pressor effect was somewhat longer than that

obtained with the other specimens. It was thought at first that this might be attributable to a stasis in the circulation through the limbs which was caused by the severe constriction of the vessels. Consequently, the scanty venous return would contain a greater concentration of cobefrin than would otherwise be found. It might also be attributable to the short duration of the perfusion which did not allow the capillary bed of the limbs to eliminate as much of the pressor substance as it did in two and three hours.

TABLE III

HEART-LUNG-HINDLIMB PERFUSION EXPERIMENT

TIME	VENOUS RETURN, C.C. OF BLOOD PER MINUTE	SPECIMENS TAKEN FOR TESTING; REMARKS
12:00 M.	130	Specimen (10 c.c.) for control
12:12 P.M.	135	15 mg. cobefrin added to arterial circuit
12:15	5	Marked reduction in venous return
12:22	4	
12:27	6	Specimen 1 (10 c.c.); perfusion for fifteen minutes
12:31	10	Blood very venous
12:42	14	Specimen 2 (10 c.c.); perfusion for half an hour
12:55	20	
1:12		Specimen 3 (10 c.c.); perfusion for one hour
1:25	48	
1:30		Oxygen introduced into venous reservoir
1:36	64	
1:42	85	Specimen 4 (10 c.c.); perfusion for an hour and a half
1:51	110	
2:00	120	
2:09	135	
2:12	135	Specimen 5 (10 c.c.); perfusion for two hours
2:14	133	
2:17	132	
2:18	134	15 mg. cobefrin added
2:20	25	Marked reduction in venous return
2:28	22	
2:46	14	Specimen 6 (10 c.c.); perfusion for two and a half hours.
3:00	20	15 mg. cobefrin added
3:12		No further reduction in venous return

In view of the fact that there was such a marked vasoconstriction in the tissues of the hind limbs, several other preparations were made and cobefrin was added slowly in graduated amounts to the arterial side of the perfusion circuit. We anticipated that small doses of cobefrin added at intervals would eliminate the intense degree of constriction and thus allow the limbs to carry on the perfusion more satisfactorily. Unfortunately, this did not hold true. In one experiment, practically identical with the one just described, with animals which were approximately the same size, we added slowly 5 mg. of cobefrin instead of 15 mg., but in spite of the smaller dosage the same marked vasoconstriction occurred. The perfused tissue responds to additional

amounts of cobefrin provided an interval of from one to two hours has elapsed between the injections. When the interval is less than one hour, further addition of cobefrin does not affect the vasoconstriction which is still present, nor does it increase the cardiac rate. At the termination of the experiment the skeletal muscles of the limbs were examined and were found to be in excellent physiologic condition; there was no evidence of rigor, and the muscles responded vigorously to stimulation by the inductorium set at 8 cm.

Examination of specimens of blood obtained from the hind limbs indicated that the capillary bed of the limbs was just as effective in destroying cobefrin as that of the liver. Within thirty to forty minutes the hind limbs had removed nearly all of the cobefrin which they were capable of removing. Protracting the experiment to three and four hours resulted in very little, if any, further elimination of the drug, as determined by response of the blood pressure of the test animal.

HYPERGLYCOGENIC ACTIVITY OF COBEFRIN

It is known that the injection of epinephrine, pituitrin, or thyroxin causes hyperglycemia by a rapid mobilization of glycogen in the liver, and that these substances, especially epinephrine, are more effective in a well-fed animal than they are in a fasting or diabetic one. The fact that an animal in a rather poor state of nutrition, with a persistently low value for the blood sugar responds poorly to administration of epinephrine is shown in the following experiment which we carried out.

A dog weighing 16 kg. was not fed for twenty-four hours and then was given 0.6 c.c. of 1 to 1,000 solution of pure epinephrine and 10 c.c. of physiologic saline solution intravenously. Specimens of venous blood were taken at intervals during a two-hour period, and the respective values for the sugar were determined. It is clear from the results of this experiment that there was a negative response to epinephrine in this animal as the values for the sugar did not deviate significantly from control values.

The same animal one week later, after it had been fed milk and sirup in addition to its regular diet in the interim, was again allowed to fast for twenty-four hours prior to another injection of 0.6 c.c. of 1 to 1,000 solution of epinephrine. The values for the blood sugar in these two experiments are shown in Table IV.

A comparative study of the activity of epinephrine and cobefrin was made on several animals. In all instances, both drugs were given to the same animals, but each drug was given on a different day. The dogs used were in good condition and were permitted to fast for only twenty-four hours prior to the determination of the blood sugar. An intravenous injection of 0.6 c.c. of epinephrine when given to a dog

TABLE IV

HYPERGLUCOGENIC ACTIVITY OF EPINEPHRINE

IN DOG WITH CONSTANT LOW VALUE FOR BLOOD SUGAR		IN DOG WITH CONSTANT HIGH VALUE FOR BLOOD SUGAR	
SPECIMENS OF BLOOD	MG. OF SUGAR PER 100 C.C. OF BLOOD	SPECIMENS OF BLOOD	MG. OF SUGAR PER 100 C.C. OF BLOOD
Control	76.0	Control	125.0
10 minutes after injection	80.0	10 minutes after injection	190.5
20 minutes after injection	89.0	20 minutes after injection	161.3
30 minutes after injection	85.6	30 minutes after injection	142.8
1 hour after injection	72.0	1 hour after injection	148.0
2 hours after injection	74.3	2 hours after injection	130.7

weighing 16.0 kg. produced a rapid increase in the value for the blood sugar from a central value of 63 mg. for each 100 c.c. of blood to 112 mg. within ten minutes. The same dog three days later, after having been given 0.6 c.c. of cobefrin intravenously, showed an increase in the central value from 65 mg. of sugar for each 100 c.c. of blood to 135 mg. within ten minutes. Essentially there is little difference in the degree of increase in the blood sugar produced by cobefrin and epinephrine, and the onset and duration of the effects of the two drugs are practically identical. Within one hour after the injection of either epinephrine or cobefrin, the value for the blood sugar returned to control values (Fig. 9).

SUMMARY

In this comparative study of cobefrin and epinephrine, it has been shown that these two substances have many properties in common, and that, for the most part, their physiologic behavior is identical. There are, however, several differences which are noteworthy. Both substances produce similar increases in the blood pressure of test animals, with the exception that the activity of cobefrin generally endures slightly longer than that of epinephrine. The duration of the pressor response produced by comparable doses of cobefrin is midway between that of epinephrine and ephedrine. Epinephrine causes a more marked but shorter pressor response than does ephedrine. Cobefrin gives the same abrupt pressor response as does epinephrine; the pressor response of cobefrin lasts longer than that of epinephrine, but does not endure as long as that of ephedrine.

Barger and Dale pointed out that the maximal pressor activity of epinephrine and allied compounds was dependent on the introduction of hydroxyl groups on the para and meta positions in the basic benzene ring. Ephedrine does not have these hydroxyl groups, which probably accounts for the fact that it has less vasopressor activity.

The presence or absence of vagal reflexes during the studies of the effects of epinephrine and cobefrin on the blood pressure were not

constant in occurrence under any type of anesthesia. As a rule, neither substance gave evidence of a reflex vagal slowing with a concomitant decrease in the blood pressure. The advantage which a few clinical investigators have claimed for cobefrin is that it does not produce reflex vagal slowing of the heart. This finding was substantiated. The results which were obtained with commercial epinephrine were comparable with those obtained with cobefrin. Consequently, the use of cobefrin instead of epinephrine would appear to have no advantage in this respect. One outstanding and important difference between these closely allied compounds is that cobefrin is

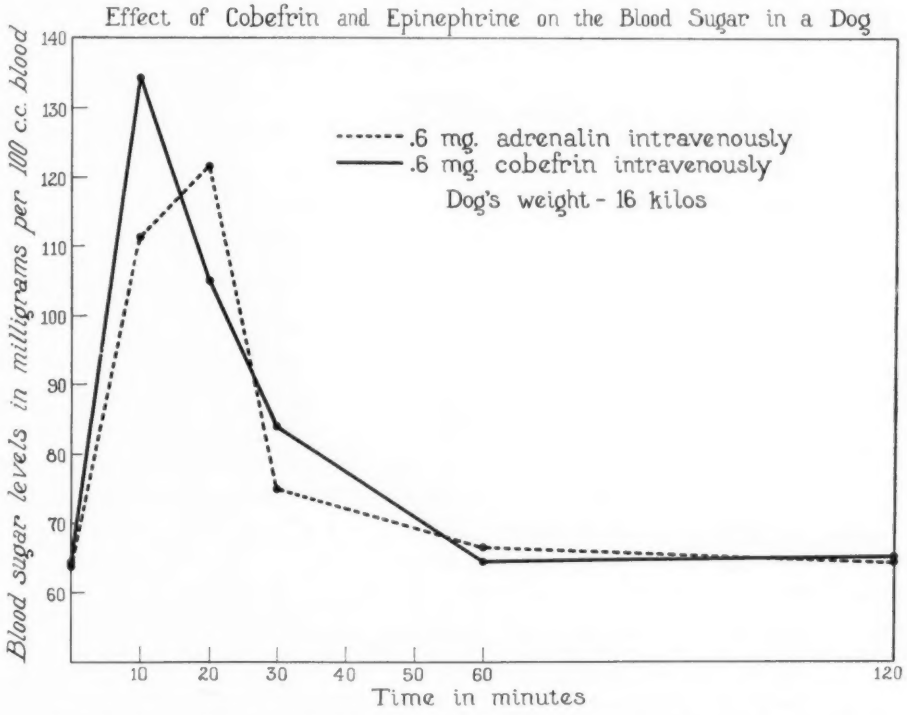

Fig. 9.—The effect of cobefrin and epinephrine on the blood sugar of a dog.

active when administered by mouth while epinephrine is not. Herein lies the one major difference in the action of these two substances.

Cobefrin was found to be just as effective as epinephrine in stimulating the perfused isolated heart of the rabbit, and the ability of cobefrin to cause relaxation of a rhythmically contracting uterus of a virgin guinea pig or to relieve bronchospasm was identical with that of epinephrine. To determine the site of destruction of cobefrin in the body, the Starling heart-lung, heart-lung-liver, and heart-lung-hindlimb perfusion preparations were employed. It was found that practically none of the cobefrin was inactivated in the heart-lung perfusion experiments, which fact coincides directly with the results of

Elliott's experiments with epinephrine. However, the heart-lung-liver and the heart-lung-hindlimb perfusion experiments indicated definitely that any large capillary bed, with the exception of that of the lungs, serves as a site for the elimination of cobefrin. The liver is by no means as specific an organ for the inactivation of cobefrin as it is for the inactivation of nicotine or novocain. Studies on the blood sugar of dogs showed that epinephrine and cobefrin were equally potent in producing definite increases in the values for the blood sugar, provided the animals were in a proper state of nutrition.

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A SUGGESTION IN THE TECHNIC OF CHOLECYSTECTOMY FOR THE COMPLICATED CASE OF GALLBLADDER DISEASE

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IN 1909, the late Dr. Archibald MacLaren and I, through his courtesy, reviewed 165 operations on the gallbladder, liver, and pancreas. I note this dusty datum from the archives to repeat a statement made in that paper which is pertinent to this discussion: "*It was found necessary to remove the gallbladder in twenty-one cases.*" Three patients died, one in seven, a mortality of 14.2 per cent.

The surgeon whose experience and study revert to the first decade of this century will support the statement that there was at that time an active discussion of the relative merits of cholecystotomy and drainage, and cholecystectomy, revolving in the main about the question of mortality. (Among the many distinguished surgeons of that period appear the names of Mayo-Robson, Moynihan, Deaver, Maurice Richardson, Murphy, and Mayo.) In 1904, Mayo-Robson reported twenty-eight cases of cholecystectomy; four patients died, one in seven—a mortality of 14.2 per cent. He remarked about the possible increase in mortality when cholecystectomy was attempted. Moynihan was definite in his opinion that every cystic gallbladder should be removed, but stated that in carefully selected cases, the mortality following cholecystectomy should be no larger than in cholecystotomy. In various other reports, the mortality following cholecystectomy ranged from 25 per cent in the French literature, to the report of Mayo of less than 2 per cent in five hundred operations. Through all that period the caution was given that the mortality may be increased by the attempt to remove the organ, leading up to the dictum of Deaver, "when in doubt, drain."

The technical phases of the operation of cholecystectomy gradually received more attention. There was an active debate, which continued over several years, upon the relative feasibility of the up-down or the down-up method of procedure. It was the demonstration of the down-up, or the so-called reverse, method of removal that stimulated the attempt to perform cholecystectomy in a larger group of cases, those instances in which a pancreatitis was demonstrated or suspected being, of

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course, excepted. In these cases, the gallbladder was purposefully left to insure drainage of the biliary system as a part of the treatment for the inflammation in the pancreas.

There is no keener procedure in surgery than that wherein the cystic duct and artery are positively identified, ligated under the sense of sight and touch, the liver attachments severed by the cut-and-sew method, with the last step of the operation, the tying off of the gallbladder at the liver notch, with the removal of the disease and the whole field completely repaired. Whereas at the beginning, cholecystectomy was used only in case of gross pathology, the accumulated experience and reports of success led to the operation in cases of mild pathology—the white-walled and the strawberry gallbladder. There were also those who advocated cholecystectomy on a purely symptomatic basis. Over the years the accumulated evidence indicates, and I think it is the general consensus of opinion, that the prime object of surgical attack on the gallbladder is its removal and that a failure to do so yields a sense of defeat in the performance of incomplete operation.

There are conditions, however, wherein the attempt at formal excision carries with it a risk of an operative misstep, a stormy convalescence, or a fatality. That such events do occur is witnessed by the ingenuous plans in the literature for the reconstruction of the common duct, the not infrequent reports of secondary operations where conditions are found producing symptoms which may fairly be placed on a technical basis. Mortality statistics of individual surgeons and special clinics show a satisfactory improvement, but recent interesting and important surveys of general clinics, where the work of many surgeons is included, indicate that the average result of operations in this field carries a mortality which is still somewhere between 3 and 4 per cent. Add conditions outside the operative field—the obese patient, incomplete exposure, inadequate relaxation of the fighting anesthesia, the aged and debilitated patient, hypertension—all these conditions and others in which the time element of the operation may be a factor in recovery may accumulate to a point where this suggested technic may have a wider application than I care to indicate and sponsor at this time. When the landmarks are clouded, when the excision carries a risk of injury to the structures about the gallbladder, when the integrity of the gallbladder wall is uncertain, I suggest this technic be considered.

To illustrate the procedure, I have resurrected an illustration now buried twenty-seven years (Fig. 1). This old plate (originally in color), showing impacted stones in the cystic duct, may not represent an unusual condition. I will say that in some of the cases operated upon by this plan, it has been a revelation to note the narrow margin of safety that the surgeon assumes in attempting cholecystectomy, whenever the base

of the gallbladder has folded over the common duct, the common duct the site of inflammatory change, or the cystic duct widely dilated. If one will visualize the large cystic, or the small contracted, gallbladder, the first step (Fig. 2*a*) is to split the wall so that the resulting wings are equidistant from the attachments to the liver. This incision is carried down, until the cystic duct is demonstrated from within. The extent of this incision lies within the judgment of the operator; I believe it should be limited to a definite margin of safety. The second step (Fig. 2*b*) is to "wing" the gallbladder by two opposed symmetrical incisions carried down to a point decided upon in the separate case, but still within a margin of safety. The "wings" are completely removed. The two steps concluded leave a strip of the gallbladder wall and mucous membrane wide enough to completely preserve the normal attachments

Fig. 1.—The cut resurrected from the article of twenty-seven years ago is shown. In the situation of impacted stones in the cystic duct, this plan of cholecystectomy would not be complete, but it would clearly demonstrate the condition. (Fig. 2, Surg., Gynec. & Obst. 8: 337, 1909.)

to the liver. In trying to find a comparison of this situation to some common resemblance, I would suggest that it looks like a ladle, the handle of which is the strip on the liver, and the cup, the mucous membrane lined base of the gallbladder. I think it worth while to keep this comparison in mind, because the success of the operation depends upon the achievement of the next step. The third step (Fig. 2*c*) is the careful dissection of the mucous membrane of the handle and the cup. The line of cleavage between it and the wall is readily found at the liver notch. Every effort is made to preserve the continuity of the mucous membrane of the handle, in order to lead to line of cleavage between the mucous membrane and the wall of the cup. This latter excision may be exacting. In one case, the tissues were so friable that all I could do was to

curette this pocket in the hope of a complete removal of the mucous membrane. In another case there was a note of uncertainty of its complete removal. Unless this step is complete, the procedure lines up with those cases wherein the amputation has been made above the cystic duct, leaving a part of the gallbladder in situ, a condition which invites the re-formation of the gallbladder, so well described by Beye.

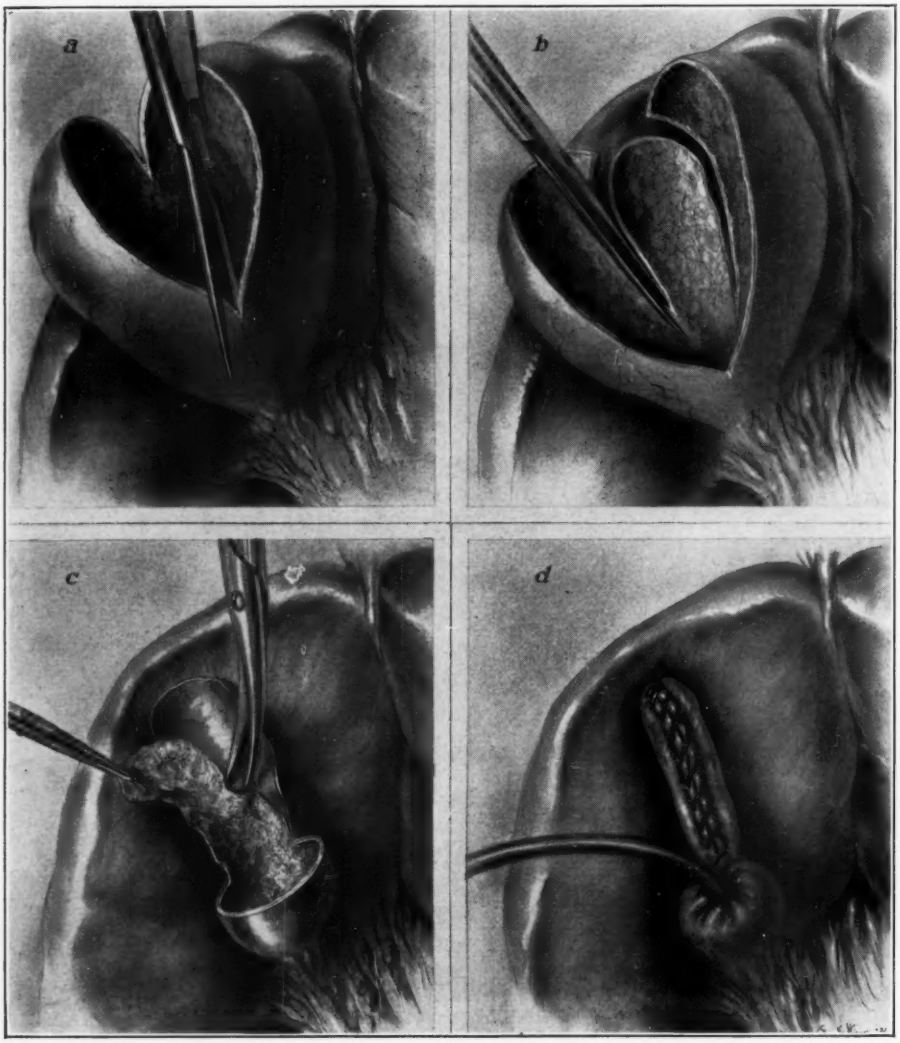

Fig. 2.—*a* and *b*. These incisions should be carefully and symmetrically made to avoid confusion of direction and extent. *c*. I asked Miss Hirsch of the Art Shop to make the picture of the ladle diagrammatic. The surgeon will visualize all sorts of combinations of width of handle and depth and irregularities of the cup. I think enough of the handle should be left to insure its suture into a cord and enough of the cup be left to allow suture about the drainage tube. I suggest the surgeon try out the dissection of the mucous membrane on those cases where the gallbladder had been removed by formal methods. *d*. It has been suggested that the tube be brought up through the handle. So far this has not been done.

The fourth step is the suture of the wall of the ampulla around a tube, and the continuation of the suture up the gallbladder wall still

adherent to the liver, in order to cover, or at least diminish in size, denuded surfaces and control bleeding.

The first objection to such a procedure is that in opening the gallbladder so widely, infectious agents are released upon the peritoneum. In this group of selected cases, the peritoneum is often involved, as shown by adhesions, and the absorbability of the peritoneum thereby is lessened. It is an established fact that the clean peritoneum will withstand gross insult with recovery, provided the time element of the irritation has not been carried over too long a period. In this case, the area is immediately drained. I have been deeply impressed by the studies of Andrews on the infectious nature of the gallbladder contents, even to the point of questioning the appropriateness of the term "empyema" of the gallbladder. I believe his studies fit with my clinical observations of such conditions. However, this is a valid objection which the surgeon must balance on the question of leaving the gallbladder with drainage on the one hand, or the attempt to remove it by formal methods under difficult and dangerous circumstances, on the other.

The second objection is that some of the gallbladder wall is left in situ. Andrews indicates that infection resides in the wall. From a clinical standpoint, this objection is of negligible worth.

The third objection is the one which has deterred me from saying anything about the plan to anyone except those in my immediate contact. This objection is that the procedure must be classed as crude, bizarre, trick surgery, which offends one's sense of propriety, when it is compared to the ideal methods. Yet I believe the operation is founded on proper surgical principle in that the mucous membrane lining is removed. Clinically it is not the wall that is often at fault, but the mucous membrane, which by its structure tends to continue its function of secretion even under the most extraordinary and adverse conditions. The procedure is comparable to that used in inflammatory ovarian cysts, in which the formal removal of the tumor was impossible, but which yielded results when the mucous membranes were removed with collapse and atrophy of the wall.

My first operation was done in 1921, without premeditation and under a sense of desperation to do something to a ragged, friable gallbladder, to complete the operation, and to get a sick patient to bed, where she was placed with an expectation of a fatality. The convalescence in this case was so free from concern that I began to wonder whether the procedure were not acceptable. The second case was a man, whom we had observed over several years, with persistent hypertension of systolic 260, diastolic 130. He developed a tumor mass in the right upper quadrant with symptoms imperative of relief. He was the first patient in whom this procedure was deliberately selected. The gallbladder was removed, as above described, with less concern than often follows the ordinary case. The man lived for several years to die of apoplexy.

I had hoped to have an impressive series of cases to report, but I have found but sixteen done by my associate, L. E. Daugherty, together with, or by, myself. The mortality has been nil. In but one case was there complication. I shall conclude my paper by an abstract of this case, which will give the picture of conditions under discussion:

CASE REPORT.—B. H., seventy-two years old, entered St. Luke's Hospital, St. Paul, Minn., June 14, 1933. *Previous illnesses:* Typhoid fever thirty years ago, suppurative appendicitis twenty years ago, and a severe attack of facial erysipelas one year ago—all intensely infectious diseases.

Present Complaint.—Progressive painless jaundice of three weeks' duration.

Recent History.—Has not felt well since April, 1933. Thought he had a cold and has felt weak and listless. Appetite fair—favorite foods, cabbage and fatty foods, weight loss of 15 pounds. For three weeks noticed white stools, dark urine, and itchy skin. No sharp colicky pains.

Examination.—Temperature and pulse normal, intense jaundice, achylous stools, and urinary findings of complete biliary obstruction. A palpable mass was found in the right upper quadrant of abdomen.

Preoperative Diagnosis.—(1) Carcinoma head of pancreas. (2) Gallbladder disease.

Operation.—After the usual examination and preparation for operation, the abdomen was opened to find a tense gallbladder completely hidden in adhesions which were easily separated, except at one point where time was taken to disprove perforation into the duodenum. There were stones in the gallbladder; cystic and common ducts were palpated. The gallbladder was split and many stones were removed. Several stones in the common duct were expressed through a dilated cystic duct, except one which was the site of such inflammation that the tissues of the common duct would not withhold retaining stitches. This stone was removed by sense of touch, and margins of the incision were promptly lost. An attempt to place a T-tube failed after many efforts. The gallbladder was removed by the plan above described; the cup and drainage were established. That night he suffered from acute urinary retention requiring catheterization. During the next week, more attention was given to the urinary bladder than to the wound, which drained bile through the tube in profusion. On the seventh day, the patient had a chill, high temperature, and acute delirium, and that evening the wound ruptured, requiring the usual midnight re-suture. This occurrence should be noted as it followed this particular technic. The patient recovered promptly from the second operation, bile was obtained in profusion, but there was no appearance of bile in the stools. He was discharged, to be taken care of at home. There was no bile in the stools which could not be explained by the ingestion of bile in the food.

In October, 1933, no positive improvement in local condition indicated further attack. The third operation was done at St. Luke's Hospital on October 4, 1933. The abdomen was opened to find that the handle of the ladle was a perfect guide to the common duct, which was promptly identified to find a stone which had receded into the liver sinuses at the first operation. This was removed, and a T-tube readily inserted. It was a great concern to note that there was still a debatable quantity of normal bile in the stools even after what seemed to be a careful exploration of the ducts. Gradually I came to the fear that all the manipulation of it had resulted in a constriction. This period of uncertainty was one of the most wonderful exhibitions of personal interest and professional care of this patient by his physician, E. V. Goltz. In about two months the situation began to clear up and the man, recently checked up, is apparently in splendid health.

In the literature, there are many valuable and practical suggestions and procedures other than the formal down-up and up-down methods of attack on the gallbladder—electrocoagulation, subserous cholecystectomy —and I feel sure that every surgeon must, at some time or other, have found it necessary to substitute or add steps to meet special conditions. My feeling is that should the above plan be the same or similar to any such of your steps, then I simply suggest it support these steps. I have no desire to offer anything new, but to present a plan of an emergency nature, a way out of the complicated cases, and to exclude the risks of injury to the common duct and particularly to the liver. It might interest you to scan that old article of twenty-seven years ago and read it in the light of experiences of these succeeding years. You will read an argument by MacLaren, which seems to me perfectly valid today, on the care of selection of cases for cholecystectomy in which he points out that the general surgeon should not expect a less than 2 per cent mortality in the surgery of this field. I still believe that it is no disgrace to do a cholecystotomy. MacLaren cites several cases observed over several years with no return of symptoms. His opinion was that cholecystectomy was often performed because of a fear of a second operation. He had a belief that postoperative concern was in direct relation to liver injury, or exposure of the raw surface in the gallbladder bed. I tried to collect some evidence along this line, but the findings were so variable that no conclusions could be made. Yet over the years, I have been more concerned about direct injury to, traumatism of, and exposure of denuded surfaces, than I have been over the peritoneum. The peritoneum has a wonderful faculty of recuperation. What happens to the liver?

CONCLUSION

The following arguments can be listed in support of this plan, or similar plans:

1. Speed of achievement.

2. The assurance to the surgeon of an ineffable satisfaction in the knowledge that no damage has been done to structures outside the field. The plan of excision erases the possibility of injury to the liver and the danger of secondary hemorrhage.

3. It meets the first principle of any plan for cholecystectomy, the removal of the mucous membrane.

4. It provides drainage of the biliary system for cases of suspected pancreatitis.

5. It leaves a valuable guide to essential structures should a second attack on this field be indicated.

What I offer is an odd operation based entirely on clinical experience, which has developed into a formal series of steps to meet the requirements of the complicated situations.

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EDEMA IN SURGICAL PATIENTS

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THE development of edema in surgical patients is not an uncommon occurrence, particularly since the parenteral administration of liquid has become common practice. Patients depleted by starvation, infection, and blood loss may develop edema rapidly and to extreme degree if the quantity of parenteral liquid is excessive.

According to Starling's hypothesis,[1] edema is explained by variation in exchange of water between the blood and tissues, as determined by a balance between the hydrostatic pressure in the capillaries and osmotic pressure of plasma proteins. Lack of oxygen has been shown by experiment to increase the permeability of the capillary walls, permitting filtration of fluid and protein from the capillaries into the tissues.[2] Leiter[3] was the first to attempt alteration of the osmotic pressure by depleting the plasma proteins by plasmapheresis. Since then, many variations of these experiments have developed, and a definite relationship between plasma protein depletion and the development of edema has been established. Jones and Eaton,[4] in an excellent study, have applied this principle to surgical patients. They have referred to this edema as nutritional, since they feel that undernutrition is the principal factor in the pathogenesis of protein depletion. As contributing factors, they have mentioned blood loss, purulent drainage, and the general effects of sepsis. Jones, Eaton, and White[5] observed in experimental animals that edema accumulates in the parenchymatous organs, as well as the subcutaneous tissues and draw the very reasonable conclusion that the cardiorespiratory apparatus will not function normally with an excessive quantity of water in the muscles of the heart and tissues of the lungs. Weech, et al.,[6] in extensive experiments on dogs rendered edematous by inadequate protein intake and plasmapheresis, found that edema was not produced in the absence of salt intake. Other experiments indicate that the sodium ion is the edema producing element rather than chloride, since sodium bicarbonate produces edema, and potassium chloride results in weight loss and decrease of edema.[7]

The relationship of total serum protein depletion in the blood and the development of edema depends almost entirely on the depletion of the serum albumin content of the blood plasma. Bruckman and

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Peters[8] indicate that edema almost invariably develops when the serum albumin falls below 3 per cent in patients with malnutrition. It is their opinion that osmotic pressure is influenced far more by albumin than by globulin. Moore and Van Slyke[9] conclude that the tendency to edema in nephritis, except in rare cases, appears to be correlated about as closely to the total protein as to the albumin fraction. They estimate that edema is usually present with a total protein of 5.5 ± 0.3 per cent, or albumin 2.5 ± 0.2 per cent. The point in the reduction of total protein or serum albumin at which edema appears has been termed the "critical level."

A series of twenty-eight surgical cases has been studied in the University of Kansas Hospitals in an effort to determine the type of sur-

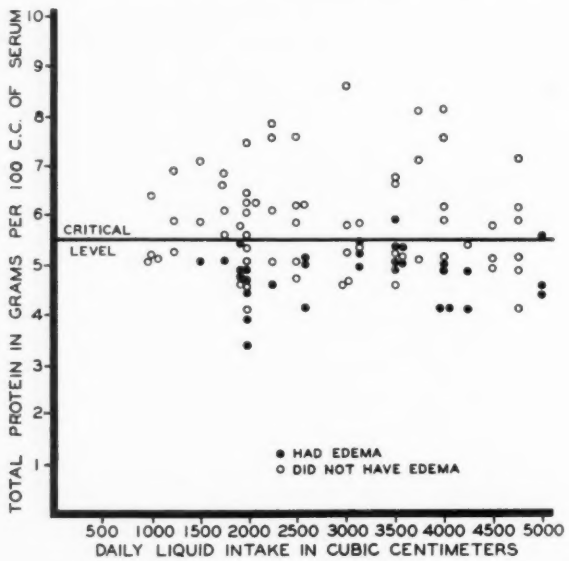

Fig. 1.—Ninety-seven total serum protein determinations in twenty-eight patients.

gical patients most likely to develop protein depletion and edema, the effect of low serum protein and edema on prognosis, and the most effective method of combating such changes. In this series are included eight cases of appendicitis with peritonitis, four cases of appendical abscess, two cases of perforated peptic ulcer, three cases of intestinal obstruction, four cases of carcinoma of the stomach, and one case each of Banti's disease, hypernephroma, simple acute appendicitis, second degree burns, Pick's disease, pyloric obstruction, and hypertrophied prostate. These cases were selected, either because they presented evidence of edema, or because there was reason to expect protein depletion because of impaired nutrition. The group of gastric malignancies and peritonitis cases were treated by gastric suction and thus subjected to starvation. Repeated blood protein determinations were made and fluid intake and output recorded. The

solutions used were 5 per cent dextrose alone, or in physiologic sodium chloride solution, or Ringer's solution. These solutions were at times modified to suit the body sodium chloride requirement.

If one studies all twenty-eight cases from the standpoint of total protein levels and the occurrence of edema, it is quite apparent that edema is closely associated with diminished total protein. Practically all of the cases presenting clinical edema had a total protein content of the blood of 5.5 gm. or less. However, several cases with a lower reading had no edema. Since the quantity of fluid intake influences the occurrences of edema, the total protein readings have been graphed with relation to the amount of fluid intake (Fig. 1). As can be seen in the chart, edema occurred in patients receiving 1,500 to 2,000 c.c. of solution daily. This may be explained in part by the fact that five of the

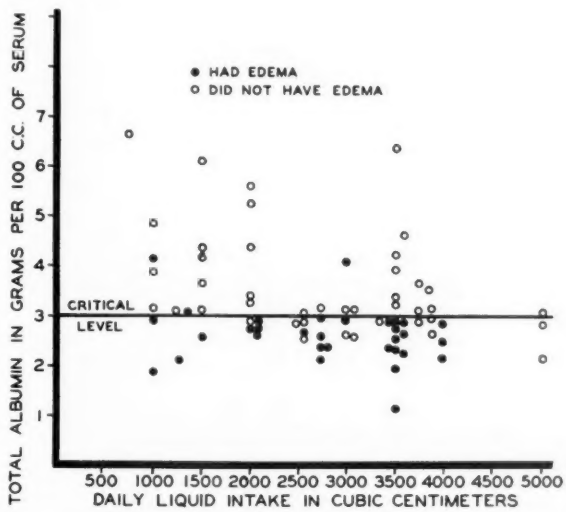

Fig. 2.—Seventy-four serum albumin determinations in twenty-eight patients.

patients were under sixteen years of age and received less total fluid, but as much or more in proportion to body weight than the adults. In several adult cases, receiving 3,500 c.c. or more of saline solution, edema was present when the total protein level was six gm. or more. The "critical level" of the serum albumin in this series is approximately 3 gm. per 100 c.c. of blood (Fig. 2).

In this study it was noted that those patients having gastric lesions or peritonitis were more likely to show a decrease in protein and to develop edema.

It is quite apparent that there is a close parallel between the decrease in total protein and the albumin fraction. The globulin is independent of this decrease and often increases, producing an inversion of the albumin-globulin ratio.

In an analysis of the cases from a standpoint of edema and prognosis, it can safely be said that only those cases seriously ill develop

TABLE I

BRIEF CASE REPORTS OF THREE PATIENTS WITH PERFORATION OF THE APPENDIX AND PERITONITIS. EARLY APPENDECTOMY WITH DRAINAGE. RECOVERY. EDEMA DISAPPEARED IN ALL CASES IN THREE TO FIVE DAYS AFTER DISCONTINUING SODIUM CHLORIDE INTAKE AND STARTING FOOD BY MOUTH

SEX AND AGE	POST-OPERATIVE DAYS	TOTAL SERUM PROTEIN, GM. PER 100 C.C.	SERUM ALBUMIN, GM. PER 100 C.C.	SERUM GLOBULIN, GM. PER 100 C.C.	NONPROTEIN NITROGEN, MGM. PER 100 C.C.	WHOLE BLOOD CHLORIDES, MGM. PER 100 C.C.	PROGRESS NOTES
Male, 69	6	5.04	2.87	2.17	37	470	Edema appeared on eighth postoperative day. Average daily intake of Ringer's solution, 2,600 c.c. Transfusion of 500 c.c. of blood on twelfth postoperative day.
	9	5.08	2.69	2.39	40	500	
	12	4.08	2.59	1.51	32	410	
	16	6.29	3.09	3.20	31	450	
Male, 23	0	5.83	3.96	1.87	34	450	Edema appeared on sixth postoperative day. Average daily intake of Ringer's solution, 3,250 c.c. Transfusion of 400 c.c. of blood on seventh postoperative day, and 500 c.c. on twelfth postoperative day.
	4	5.26	2.98	2.28			
	8	5.23	2.37	2.86	30	470	
	16	5.01	1.03	3.98	29	480	
	19	5.45	2.77	2.68			
Male, 12	5	5.44	2.71	2.73	25	400	Edema appeared on fifth postoperative day. Average daily intake of Ringer's solution, 2,000 c.c. (weight of patient 99 pounds). Blood transfusion of average 375 c.c. on seventh, ninth, thirteenth, and fourteenth postoperative days. Began protein feeding on eleventh postoperative day.
	7	4.95	2.86	2.09			
	10	4.95	2.51	2.44			
	11	5.68	2.81	2.82	27	450	
	16	4.47	2.09	2.38	35	450	
	22	7.56	3.06	4.50	24	445	

edema. Of the twenty-eight cases, fourteen presented clinical edema, and, of these fourteen cases, five died. Included in the list of five deaths are one case of Pick's disease, one of Banti's disease, one of carcinoma of the stomach, and two with perforated appendix and peritonitis. It is doubtful if the first three deaths were influenced in any way by edema. It is possible that edema might have been a lethal factor in the two cases of peritonitis. One of these patients had pulmonary edema. While it is impossible to state with certainty that the development of edema influenced the death rate in this series, we can say with assurance that all patients having edema were seriously ill.

In each of those cases developing edema, particularly the peritonitis cases, an effort was made to replenish the blood proteins by blood transfusion and, in this way, relieve the edema. A transfusion of 500 c.c. of blood has little effect on the total protein content of the blood serum. A single transfusion cannot be expected to raise a depleted blood protein of the recipient a great deal, since the donor's blood contains only the normal quantity of total protein which is greatly diluted by the recipient's blood. However, repeated transfusions are beneficial and usually effect a gradual rise in blood proteins. It is impossible to say from our data whether blood transfusions have a desired effect on the edema, since the intake of water and sodium chloride was reduced as soon as edema appeared. In several instances, it was noted that the urinary output was increased following such measures.

SUMMARY

Returning to our original three questions in summary, it can safely be stated, from the study of these cases, that the patient most likely to develop surgical edema is one subjected to starvation associated with an infection such as peritonitis. Edema need not be expected if the total serum protein is not permitted to fall below the critical level, and if the intake of sodium chloride is not excessive. Edema appeared only in those cases of prolonged and serious illness, and for this reason the occurrence of edema in any surgical patient is one of the many signs suggesting the seriousness of the illness and a possibly unfavorable outcome. When the development of this complication occurs or is imminent, as shown by blood protein depletion, repeated transfusions are indicated. If edema develops, the intake of sodium chloride should be immediately discontinued. A 5 per cent dextrose solution may be given to supply the necessary liquid.

CONCLUSIONS

Because of the danger of edema, parenteral feeding and watering should be discontinued as early as possible. The sick surgical patient should have food and water by mouth as soon as they can be tolerated.

Metabolic balance cannot be maintained by giving dextrose, sodium chloride, and water by parenteral methods. With a low serum protein, sodium chloride is the principal edema producing factor when administered in excessive quantities.

In this series of twenty-eight patients, those having gastrointestinal disease, to whom food could not be given by mouth for several days, showed the greatest tendency to develop edema.

While evidence that patients with low serum protein and edema are favorably influenced by transfusions is not conclusive from our observations, we believe that repeated transfusions are indicated when protein cannot be immediately given by mouth.

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DIVERTICULOSIS OF THE SMALL INTESTINE: REPORT OF THREE CASES

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TWO varieties of diverticula occur in the intestinal tract, the acquired and the congenital. When all the layers of the normal intestinal wall are present in the diverticulum, it is called a true one. The familiar Meckel's diverticulum is a true congenital diverticulum. The acquired variety are of the mucous membrane hernia type and have little or no muscular fibers in their walls. This type of false diverticula may occur in any portion of the gastrointestinal tract, but it is most frequently found in the sigmoid and duodenum. This paper concerns the infrequent, acquired diverticula that occur in the small intestine.

Historical.—The literature of multiple jejunal diverticula begins with Sir Astley Cooper's description, in 1844, of numerous pouches in the upper jejunum of a sixty-five-year-old man. Sir William Osler, in 1881, recorded the case of a sixty-five-year-old male with fifty-five upper jejunal diverticula, varying in size from that of a cherry to that of a large apple. Virchow, Edel, Grassberger, Henseln, Hansemann, Hanau, and Nicholls each described cases before 1900. Klebs, Hansemann, and Hanau devoted their attention to the subject in 1896. Klebs first suggested the opinion now generally held that the pressure of fluid and gas in the intestine is the initiating force of the diverticula. Hanau produced trenchlike furrows on the mesenteric border of a loop of bowel filled with water and subjected to hydraulic pressure. In this way Hansemann produced in the intestines of old persons diverticula related to the blood vessels. Chlumsky found that the intestines of living dogs ruptured on the antimesenteric border, but that on distending intestine removed from a dog, ten hours after death, they ruptured into the mesentery. It was Klebs who first noted the relationship between the diverticula and the blood vessels; he described the site of entrance of the blood vessel through the intestinal wall as the locus minoris resistentiae. His belief that the blood vessels caused a drag upon the mucous membrane has not been substantiated.

Graser, in 1899, thought venous congestion was a factor in causing a weakened area in the bowel wall. In 1900, Sudsuki suggested that the degeneration of the connective tissue sheath of the veins produced a site of lowered resistance. Fischer, in 1900, held that chronic constipation, traction, chronic passive congestion, and gas pressure were of etiologic significance. He found that the circular muscle first disappeared with the outer coat remaining intact for some time. After the diverticula attained a large size, the outer muscular coat also disap-

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peared; once the herniation had started through the gap produced by the blood vessel, it then followed the line of least resistance, which was not always along the blood vessel. Beer reviewed the subject in 1904. Gordinier and Sampson described a case, diagnosed at operation, in 1906. The roentgen diagnosis of the condition was first described by Case, in 1920, who reported the first case so diagnosed.

By 1924, Watson found that twenty-nine cases of jejunal diverticula had been recorded; in 1935, Rosedale found seventy-one recorded cases. As yet, less than 100 cases have been reported. Recent reviews of the subject have been written by Chapman, Edwards, Schmidt and Guttman, and by Rankin and Martin.

Incidence.—Case found an incidence of 1 in 1,000 (0.1 per cent) in 10,000 consecutive barium meal examinations, as compared with 1 in 200 (0.5 per cent) postmortem examinations done at Johns Hopkins Hospital. Rankin and Martin reported that 1 case to 36,357 barium examinations of the stomach and duodenum were found at the Mayo Clinic; however, 3 cases were found at the Mayo Clinic in 957 stasis examinations of the small intestine. Larimore and Graham found 3 cases in 3,446 complete gastrointestinal studies. Rosedale found 3 cases in 5,000 autopsies. Edwards found 5 cases in 881 autopsies during the past four years when particular search for the condition was made, an incidence of 0.57 per cent which he feels is quite accurate. From these statistics, it is evident that many cases will not be found by the pathologist or roentgenologist who does not examine the small intestine with the condition in mind.

Age and Sex.—Chapman found in his review that 13 were males, averaging 62.8 years of age, and 8 were females with an average age of 59.7 years. In Rankin and Martin's 52 cases from the Mayo Clinic, there were 38 males; the average age of the group was 55.6 years, and the ages varied from 21 years to 82 years. The diagnosis was made at operation in two cases, and in each case the patient was 65 years of age. The average age of the 11 cases reported by Edwards was 56 years; 8 of his patients were males.

Pathology.—For a detailed description of the condition, the reader is referred to the recent article by Edwards, who has summarized his findings as follows: The diverticula may be either single or multiple, the site of herniation corresponding with the site of entry of the blood vessel; thus the diverticula are typically located on the mesenteric border. In case of a diverticulum on the antimesenteric border, the opening corresponds with the entrance of an unusual vessel. During their formation, the diverticula carry with them a layer of muscle which is absent in the fundus of the large diverticula.

Fig. 1 is a photograph of a portion of the specimen removed from the first case seen in the Guthrie Clinic. This site shows the variations in the size of the diverticula and also shows their situation in regard to the mesenteric line. It is noted that all the diverticula shown, with

the exception of one very large one on the extreme right, arise on one side or another of the mesenteric line. At no place was there symmetrical herniation on each side of the mesenteric line. The medium-sized bilobed diverticula were formed by two diverticula on the same side of the mesenteric line, becoming continuous. Only rarely did the fusion occur across the mesenteric line, and then only when the diverticulum was of exceptional size.

The relation of the blood vessel to the diverticula is shown in Figs. 2 and 2*A*. This also shows the extreme variation in the size of the diverticula that may be present in one segment of the bowel. The small diverticula have only one vessel related to them. After fusion of two or more diverticula has taken place, there are two or more vessels related to the ultimately formed diverticulum.

The large diverticula are very thin and transmit light readily. Their walls contain only mucous membrane and serosa. In the small diver-

Fig. 1.—Portion of small intestines removed from Case 1. All sizes of diverticula are present. The relation to the blood vessels is shown in several places. The point of origin on either side of the mesenteric line is clearly shown near the midportion. The medium-sized diverticulum on the left is of the bilobed type. On the extreme right is one of the few diverticula in the whole specimen removed that extends across the mesenteric line and thus was formed by fusion of two smaller diverticula, originally on both sides of the mesenteric line. Note the increased diameter of the bowel in the region of the larger diverticula.

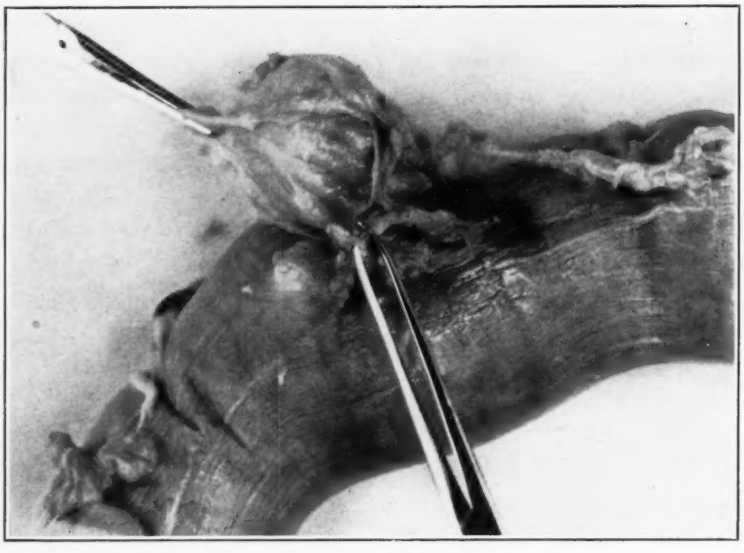
ticula, the wall is found to increase in thickness since there has been less stretching of the wall. Muscle fibers are present in the smaller diverticula. The diameter of the bowel is increased where many diverticula are present close together.

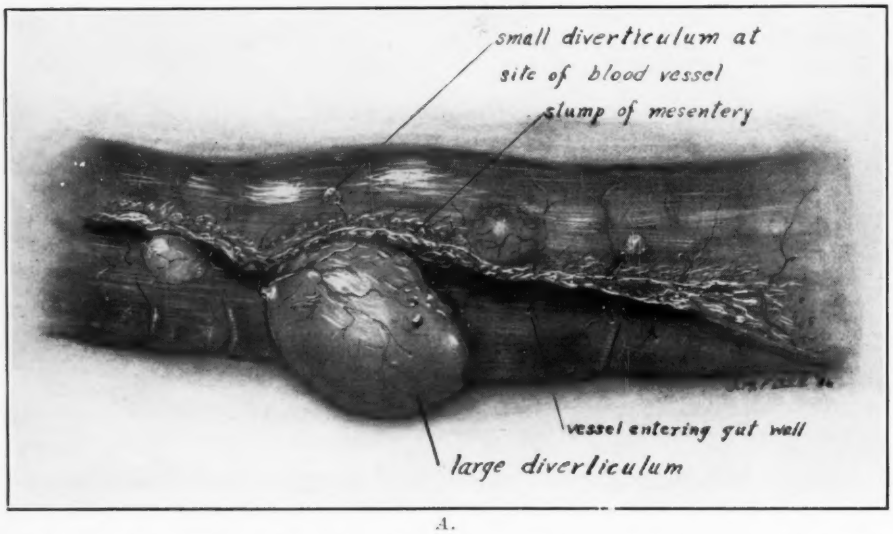
Figs. 3 and 4 are photographs of the specimen from the third case seen at the Guthrie Clinic. The specimen was resected at operation, and the ligatures on the mesentery are not to be confused with the diverticula. The condition is not as far advanced as in the first specimen, but otherwise differs in no essential from it.

Pathogenesis.—Edwards states that there is no doubt that the type of diverticula under discussion are acquired deformities. Their pathologic anatomy is to be explained only by the thesis that the pouches are hernias of the mucous membrane through the muscular wall of the

intestine. Since the origin of the diverticula corresponds exactly with the point of entry of the blood vessel through the muscular coat, it is generally agreed that this forms the locus minoris resistentiae, first mentioned by Klebs.

Klebs believed that the vessels produced a drag upon the intestines; Helvestine thought short selerosed vessels were a factor; Beer held that





A.

Fig. 2.—Portion of specimen from Case 1. The clamp and forceps are attached to the blood vessels. Several vessels are in relation with the large diverticula, only one with the small ones. *A*, Variety of symptoms shown by above reported cases.

degeneration of the intestinal musculature was present; Braithwaite suggested a parasyphilitic origin; Sudsuki thought degeneration of the connective tissue sheath of the veins was present. A myogenic cause was advocated by several writers, such as Roth's fatty degeneration,

Buzzi's congenital hypoplasia, and Spriggs and Marxer's toxic myositis. Jordan and Lahey assume that the acquired type is due to congenital anatomic or pathologic weakness. Rankin and Martin believe that the

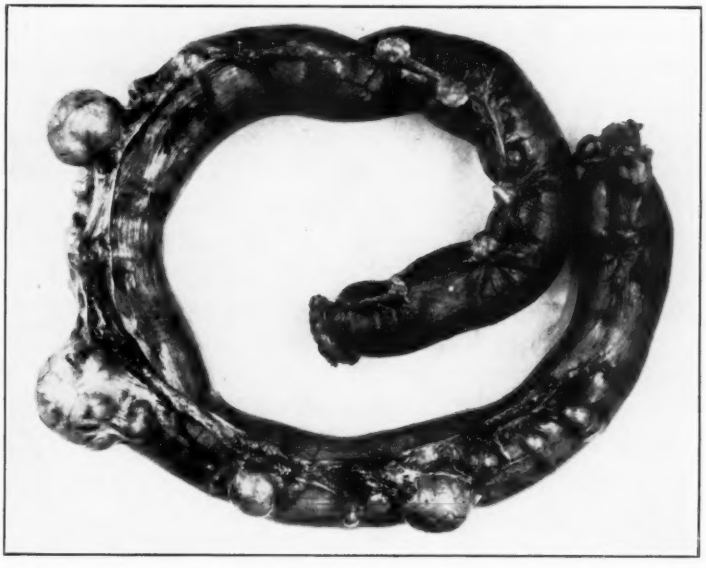


Fig. 3.—Specimen of small bowel removed from Case 3. The mesentery has not been dissected, and the ligatures placed at operation are in place and form the mesenteric line. The diverticula are seen extending to one side of this line, almost all of them on the same side. Without some dissection, the mesentery recognition of seven of the twenty-two diverticula is difficult.

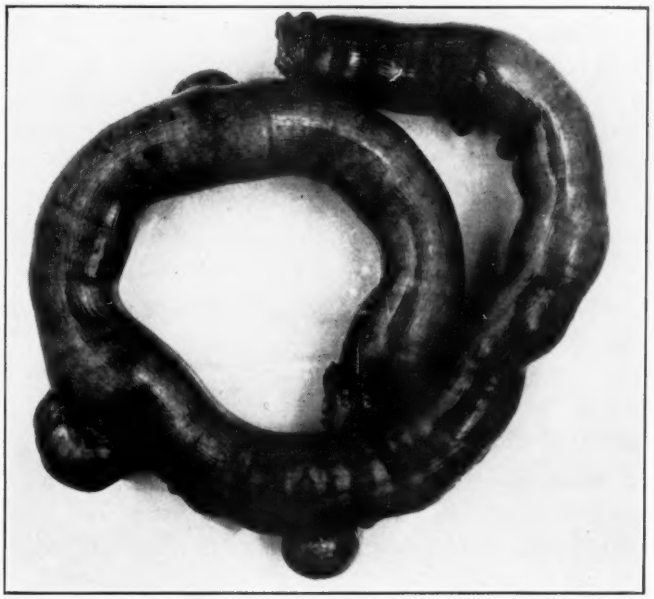


Fig. 4.—Same specimen as in Fig. 3, viewed from the antimesenteric border.

outstanding features are an inherent weakness of the wall of the bowel and an increased intraintestinal pressure; they believe that congenital weakness, obesity, venous stasis, and constipation are predisposing

factors. Chapman attempts to explain diverticula formation as a process analogous to aneurysmal formation: "changes in the connective tissue, loss of elastic tissue, something analogous to hyaline changes in the submucosa and finally hammer-like changes in pressure due to rapid contractions alternating with periods of complete emptiness." Edwards explains the increased intraintestinal pressure on the basis of irregular contractions of the musculature: "As the contents are prevented from passing along the bowel by the irregular contraction, the pressure in the relaxed portion is increased and the contents are being squeezed against the mucous coat and tend to push between any interval that can be found between the muscle fibers. The vascular channels, gaping to their fullest in the relaxed muscle wall, offer the mucous membrane loci minoris resistentiae." Barling described an early stage of diverticulosis of the colon that was observed at laparotomy: "The bowel suddenly narrowed at one point till it was no thicker than the index finger, it became extremely rigid and while the spasm lasted, tiny saccules appeared between the longitudinal bands, lying like beads along the sides of the gut. In a few seconds the spasm passed off and the tiny projections could no longer be seen."

Thus all are agreed that the two major factors are the point of decreased resistance at the site the blood vessel enters the bowel, and the increase in the intraintestinal pressure. Edwards' explanation is the most logical and is substantiated by laparotomy and roentgenologic observations. It is highly probable that the three patients here reported were sufferers from irregular intestinal contractions. The first patient developed a duodenal ileus and died on the sixth postoperative day. The high intestinal ileus may quite rightly be thought of as a very advanced degree of irregular contractions. The second patient developed a vicious cycle after a posterior gastroenterostomy which had been correctly done, as shown by the second operation. In the third case, an otherwise perfect convalescence was marred by a temporary high intestinal ileus. These findings in the three cases support the theory of Edwards that irregular intestinal contractions are an etiologic factor in the formation of diverticula, inasmuch as some form of functional derangement revealed itself in the upper intestinal tract associated with the presence of jejunal diverticula.

Symptomatology.—The two outstanding symptoms common to Edwards' four cases, in which a diagnosis of diverticula was made by means of roentgenography, were vague abdominal pains at an interval after meals and flatulence corresponding in time incident with the pain. That these symptoms can be definitely attributed to the presence of the diverticula is shown by the relief from these symptoms after the diverticula had been removed at operation. Rankin and Martin found that the majority of their cases gave no distinctive symptoms referable to the gastrointestinal tract. Tengwall states that vague digestive disturbances with occasional nausea are usually met with in diverticu-

TABLE I

RELATION OF BLOOD VESSELS TO DIVERTICULUM OF JEJUNUM

AUTHOR	ANOREXIA	NAUSEA	VOMITING	INDEFINITE PAIN	PAIN	DISTENTION	FLATULENCE	TENDERNESS	CONSTIPATION	CONSTANT DIARRHEA	HEMATEMESIS	MELENA	ULCER SYMPTOMS	ULCER PRESENT	TUMOR	RIGIDITY	ACUTE INTESTINAL OBSTRUCTION	CHRONIC INTESTINAL OBSTRUCTION	DIVERTICULITIS	PERITONITIS	PERFORATION	ENTEROLITH	CYANOSIS BOWEL	LOSS OF WEIGHT	SYNOVITIS	X-RAY	COMMENT
Gordinier and Sampson									x						x			x	x	x							1906: 16th case reported. First recognized at operation
MacKechnie	x	x	x		x					x																	
Case	x	x	x		x	x					x						x									x	1920: First case diagnosed by x-ray. 2 cases
Hunt and Cook					x	x		x																x			2 cases
Stelton		x			x																						
Baastrup					x																						
Terry and Mugler													x	x								x					
Pinneger and Burman																	x										
Christie			x				x								x						x						
Braithwaite		x	x		x	x	x	x			x														x	x	
Watson						x			x						x							x					1924: 30th case
Balfour													x	x													
Haltung												x															
Simons		x			x											x							x				
Boling		x	x		x			x								x											
Grassberger				x							x																
Stetton				x	x																					x	
Miller					x	x	x				x																
Edwards		x	x	x	x		x		x																	x	Single; excised; well 2 years
					x		x		x																	x	No operation
					x		x																			x	No operation
					x		x																			x	Resection; recovery
					x														x								Resection; recovery
Rankin	52 cases: 32 cases gave indefinite G. I., pains, bloating, and belching. 11 cases gave history of gallbladder disease.																										

losis, but that the commonest symptom is bleeding from the bowel. This is contrary to the experience of others. Braithwaite's patient vomited five pints of unaltered blood.

In five cases here reported, bleeding either from the bowel or hematemesis has been present as shown in the accompanying table. Hence the incidence of bleeding is around 6 per cent, including the case reported here.

CASE REPORTS

CASE 1.—A seventy-year-old, white male entered the Clinic May 18, 1929, complaining of loss of weight and strength for the preceding year. During the preceding

Fig. 5.—Case 1. Portion of jejunum (five feet) removed.

month, he had had a diarrhea that had started suddenly; previously, he had never had any bowel or stomach trouble of any kind. The stool contained considerable mucus, but no blood. His local physican had given him some medicine which he thought might be the cause of his expectoration of considerable material. During the few days prior to admission, he had vomited on several occasions. His past history was essentially negative. Physical examination showed a man weighing 155 pounds, who had recently lost considerable weight; his normal weight was 215 pounds. He had several bad teeth; his tonsils were enlarged; his blood pressure was 122 systolic and 80 diastolic. Examination of the chest and abdomen revealed no abnormalities. He had several large external hemorrhoids, and his prostate was moderately enlarged.

Further studies of the patient in the hospital revealed the following: red blood cells, 5,440,000; hemoglobin, 85 per cent; white blood cells, 8,200; differential,

77 per cent neutrophiles, 23 per cent small lymphocytes; blood sugar, 91 mg. per 100 c.c. of blood; blood urea, 46 mg. per 100 c.c. of blood; urine, negative; stomach contents, no free acid, combined acid, 19 to 31 units; stool, occult blood positive; gastrointestinal series, stomach riding high with considerable narrowing of the pylorus, no retention or evidence of ulcer. The temperature, pulse, and respiration were normal during the period of study.

A preoperative diagnosis of carcinoma of the stomach was made and operation advised. At operation on May 29, 1929, many (70) diverticula of varied sizes of the jejunum were found (Fig. 5). These began four inches from the ligament of Treitz and extended down the jejunum five feet. The first foot of the jejunum was bound down with peritoneal adhesions causing an acute angulation. This portion of the jejunum was twice normal size. The large intestine, stomach, duodenum, and gallbladder were negative. The involved portion of the jejunum was resected and an end-to-end anastomosis performed. The course following operation was stormy. The temperature remained normal; the pulse rate varied from 100 to 120. Frequent gastric lavage was necessary. The clinical picture was that of a high intestinal obstruction which was considered to be paralytic. The patient died on the sixth postoperative day. Postmortem examination was limited to the operative incision. The peritoneal cavity was free from infection. The end-to-end anastomosis was patent, and no point of obstruction could be discovered. The intestines were normally collapsed.

CASE 2.—The patient was a sixty-year-old male, father of a former Packer Hospital interne; a strong personal interest and an added sense of responsibility were thus present in the desire to relieve this man of his trouble. His first admission, which was of three days' duration, was December 28, 1934. His complaints were of abdominal pain after meals and at night relieved by soda and by vomiting. During the preceding two months, this had become progressively worse. Hematemesis and melena were absent. Physical examination was essentially negative. Laboratory studies revealed the following: red cells, 4,040,000; white cells, 7,200; 57 per cent neutrophiles, 43 per cent lymphocytes; urine contained 3.5 per cent sugar; blood sugar, 210 mg. per 100 c.c. of blood; blood urea, 31 mg. per 100 c.c. of blood. Free hydrochloric acid of the stomach ranged from 26 to 80 points, total acid ranged from 50 to 96 points. Roentgenographically the stomach was slightly up and over to the right. There was a small amount of ragged narrowing of the pyloric ring extending into the base of the cap; this was easily smoothed out. Peristalsis was slightly exaggerated and motility was good. That portion of the jejunum which lies immediately under the pyloric end had a strong suggestive appearance of a diverticulum which might be due to adhesions (Fig. 6). We were suspicious of pathology at the pyloric end of the stomach. No retention at five hours.

A diagnosis of peptic ulcer, or possible malignancy, and of diabetes mellitus was made. Before leaving the hospital he was given a diabetic diet and a prescription for belladonna and alkaline powders. Operation was advised.

The patient returned to the hospital on January 5, 1935. He was prepared and operated upon January 9, 1935. At operation a chronic duodenal ulcer was found. Considerable difficulty was experienced in locating the first part of the jejunum. During the early part of the operation, the patient stopped breathing several times. Gastroenterostomy was decided upon; no diverticulum was found in the loop of jejunum anastomosed to the stomach and in the relief of the anxiety over not finding a malignant lesion, exploration was not carried further. Two weeks after operation, the patient began vomiting, associated with epigastric distress. Roentgenographic examination with a small amount of barium revealed slightly exaggerated peristalsis, the stomach emptying more through the duodenum than through the stoma, and an apparent rubber hose kinking of the jejunum distal to the anastomosis. This appeared to regurge, completing the vicious cycle. At the

end of one hour, there was very poor motility of the small intestine; at three hours, there was 50 to 60 per cent retention in the stomach; and at six and one-half hours, there was 30 per cent retention.

A second operation was performed three weeks after the first operation. In the middle of the proximal loop of the jejunum, a large diverticulum was present; a second was present 12 inches below; and a third 20 inches below. Each was thin walled and on the mesenteric border. The presence of the ulcer was verified and the gastroenterostomy stoma was patent. The first and second diverticula were dissected free down to the base, the base crushed and ligated, a purse string of catgut run around the base, diverticula removed, and the stump treated with merthiolate

Fig. 6.—Case 2. Roentgenogram showing a large diverticulum of the jejunum.

and inverted. The outer coats of the bowel were closed over the stump with interrupted chromic catgut sutures; the rest in the mesentery was closed. The third diverticulum was small and was not removed. Because of the reported obstructive point from which the food or bismuth was regurgitated back into the stomach, it was decided to do an enteroenterostomy. Since the cause of the regurgitation was not mechanical, and in view of the poor intestinal motility with regurgitation into the stomach as shown by fluoroscopy, the cause of the vicious cycle may quite likely have been a functional derangement of muscular coordination corresponding to the irregular contractions described by Edwards.

The diverticula removed were approximately the size of an English walnut, one larger and one smaller. The walls of both contained many small bulging saccules

that were very thin and translucent, showing that they had formed from the coalescence of smaller diverticula and were the type of acquired, mesenteric, pulsion diverticula under discussion. Following operation, the general condition of the patient gradually improved, and he was discharged after four weeks.

CASE 3.—A white male, fifty-four years old, entered the hospital February 8, 1936, because of several large hemorrhages from the bowel. During the preceding year, he had occasionally experienced attacks of mucous diarrhea that he attributed

Fig. 7.—Case 3. Roentgenogram taken five hours after barium meal, showing retention of barium in several diverticula.

to dietary indiscretions. Six weeks previous to admission, the diarrhea recurred. At this time, the stool contained large quantities of mucus and occasionally some blood. Quite regularly he awoke at 4:00 A.M. and passed a loose stool without discomfort. He had not lost weight or strength. The patient was very apprehensive on admission, his skin was moist, and he was slightly pale. His blood pressure was 170 systolic and 100 diastolic, and there was systolic murmur over the precordium. Abdominal examination was negative to palpation. The rectum contained a mass of old blood. Laboratory examinations revealed: red cells, 3,700,000; white

cells, 7,200; neutrophiles, 65 per cent; lymphocytes, 35 per cent; urine, negative; Kahn, negative; blood urea, 38 mg., and blood sugar, 75 mg. per 100 c.c. of blood; platelets, 200,000; coagulation time, 6 minutes; bleeding time, 30 seconds. A whole blood transfusion was given February 10, 1936.

The intestinal tract was cleaned out very slowly, using mineral oil and mild laxatives. For this reason, several proctoscopic examinations were not satisfactory because of the old blood. After the blood was all removed, no abnormalities were found by proctoscopic examination. Two barium enemas were given; these revealed spasticity of the rectal pouch and some narrowing of the sigmoid. Two areas were

Fig. 8.—Case 3. Roentgenogram of barium-filled portion of jejunum removed at operation.

suggestive of diverticula. The terminal ileum showed some gaseous distention. Air injection was done, but no gross pathology could be demonstrated. After a thorough cleansing of the intestinal tract, a delayed barium meal examination was made. The stomach and duodenum were normal. After five hours, the stomach was empty, and the meal was distributed throughout the terminal ileum. A few small dilated portions of the small bowel had retained the barium. These were interpreted as diverticula of the small bowel (Fig. 7).

At operation on February 20, 1936, twenty-two varying sized mesenteric diverticula of the jejunum were found, beginning four inches from the jejunoduodenal junction

and involving the next twenty-three inches (Figs. 3, 4, and 8). Four of the diverticula were large, and seven were medium sized. The involved portion was resected and an end-to-end anastomosis done with the Rankin clamp. The convalescence was smooth until the tenth day; at this time, daily gastric lavages became necessary for four days. A flat plate of the abdomen taken on the fourteenth day showed distention of the stomach and duodenum. The obstruction to the lumen was thought to be due to a plugging of anastomosis or to a duodenal ileus. Following the administration of castor oil, the condition righted itself. The patient was discharged from the hospital on March 22, 1936. He was seen again on May 22, 1936, and had gained twenty pounds in weight, was working hard, and felt better than at any time during the preceding year. He reported by letter, dated July 10, that he was well.

The common findings of these three cases were: the sex, all were males; the age, fifty-four years of age or older; and the type of diverticula found. The first patient had the most advanced pathology and was the oldest; his age was seventy years; he had seventy diverticula in 60 inches of small bowel. A duodenal ulcer and diabetes mellitus were coexistent in the second case. The third was one of these rare cases where a diagnosis could be made by roentgen examination, and thus a diagnosis was made before operation. This case was also rare in that profuse rectal bleeding was the chief complaint. Further, the operation was the ideal procedure of resection and anastomosis, and the patient is now in perfect health. Two of these patients had a mucous diarrhea before admission, and all three had some derangement of the function of the upper intestinal tract after operation. We are inclined to the belief that this latter manifestation is in favor of the theory of Edwards that irregular intestinal contractions play a part in the etiology of the formation of diverticula.

Complications.—The complications of diverticulosis are diverticulitis, hemorrhage, perforation, intestinal obstruction, and enterolith formation. The development of these conditions may be as follows: Infected material enters the diverticulum from the bowel where it becomes shut off. The prolonged contact with the mucous membrane which has its blood supply impaired due to the ballooning, favors the development of an inflammatory process. This process may erode a vessel, resulting in hemorrhage. The hemorrhage may also result from tearing of a blood vessel when the diverticula become excessively distended. The inflammatory process may involve the serosa which then becomes sealed to the surrounding structures and causes a partial or an acute intestinal obstruction; or the process may rapidly erode through the wall, perforate, and cause a general peritonitis. The material that enters the diverticula may become hardened and form an enterolith.

Diagnosis.—A diagnosis from clinical examination alone has not been done. A diagnosis preoperatively is possible when the diverticula fill partially or completely with barium, presenting a ball of barium as

described by Case. The diagnosis in Case 3 was made upon the film shown in Fig. 7. The barium balls are evident. Most cases are discovered at operation or diagnosed at postmortem examination.

Treatment.—The treatment is surgical. The process begins in the sixth decade and is gradually progressive. The only possible means of relieving symptoms caused by diverticula is the removal of the diverticula. Resection of the involved portion of bowel is the ideal procedure. The extent of the process or the location of the diverticula may necessitate a less radical procedure. Simple excision of the diverticula or a sidetracking operation may be done.

SUMMARY

Approximately 100 cases of diverticulosis of the small bowel are on record. The condition may be diagnosed by roentgen examination or discovered at operation, but the presence of diverticula is most often established at autopsy.

Three cases are reported. The diagnosis was made at operation in two, and by barium meal in one. The latter case was confirmed at operation, the involved portion was resected, and the patient is now in excellent health. The first patient died following resection of five feet of small bowel. The second patient recovered after excision of the diverticula and an enteroenterostomy. (He had a gastroenterostomy three weeks previously for a duodenal ulcer.)

A frequent clinical picture is vague abdominal pain associated with flatulence. Based on very careful studies, the incidence is approximately 0.5 per cent (1 in 200 patients).

The two important factors in the pathogenesis are a point of lower resistance where the blood vessel enters the intestine, and an increase in the intraintestinal pressure. The development of the latter is explained on the basis of irregular intestinal contractions. According to this theory, a portion of the bowel relaxes while the segments on either side are contracting. These contractions force the mucous membrane into the gap where the blood vessel enters in the relaxed segment.

Acquired diverticula of the small bowel are usually multiple, occur on the mesenteric border, and arise in the upper portion of the jejunum.

The treatment is surgical, preferably resection of the bowel, but simple excision of the diverticula or a sidetracking operation may suit the case better.

The condition is probably one of the most frequent causes of vague abdominal complaints.

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THE DIAGNOSTIC AND THERAPEUTIC APPLICATIONS OF THE UTERINE SUCTION CURETTE

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ONE of the most frequently useful of all gynecologic instruments, in my opinion, is the uterine suction curette. I do not believe its possibilities are fully appreciated by the general profession. The old days of promiscuous curettage for all sorts of indications, including such conditions as amenorrhea, sterility, and leucorrhea, are about over, and there is now a sharp restriction in the indications for this not always simple and safe little operation. Yet there are still a very large number of cases in which the procedure is clearly advisable. In the diagnosis of the cause of uterine bleeding, for example, the curette, together with the microscope, yields information which can be obtained in no other way, and which may actually be of life and death value to the patient.

In these days of intense interest in gynecologic endocrine disorders, moreover, a great new field has been opened in which a knowledge of endometrial histology is of the greatest clinical value. It should be remembered that the endometrium is under the physiologic subservience of the ovarian hormones, and, beyond them, of the dominating gonadotropic hormones of the anterior hypophyseal lobe. This is not the place to review the effects of these hormones upon the uterine mucous membrane, but they are quite distinctive, and, to a large extent at any rate, associated with characteristic histologic changes. The endometrium is therefore a very reliable mirror of these endocrine activities, and I believe it is possible, in the present state of blood and urine hormone studies, to obtain more information as to the nature of gynecologic endocrine disorders from histologic study of the endometrium than from studies of the hormone content of the blood and urine.

In many of these cases, complete curettage is unnecessary and undesirable, especially where the histologic study must be repeated at rather frequent intervals, to determine the occurrence or nonoccurrence of cyclical histologic changes. A variety of simple ambulatory procedures have been devised for this purpose, based on one form or another of punch biopsy, aspiration, or curettage with a very small instrument.

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In most of these methods, the object is to avoid the necessity of cervical dilatation, which is a painful procedure usually requiring at least light anesthesia.

In other cases, where only a single histologic study is required, there is usually no objection, and there may be much advantage, in making the curettage a thorough one, especially as a more comprehensive picture of the endometrial histology is thus obtained. This is likewise true if the indication for the curettage is either partly or entirely a therapeutic one. Even greater is the need for thoroughness in curettage in the diagnosis of suspected pathologic lesions, for an incomplete curettage may, for example, miss an area of early adenocarcinoma.

In a very large proportion of cases of this group, the curettage can be performed without dilatation and without anesthesia, by means of the suction curette which I recently described, and I believe better by this instrument than by any of the several other appliances which have been devised for this purpose. The suction curette which I employ is, as seen in Fig. 1, simply a long cannula, with a uterine curve, and with

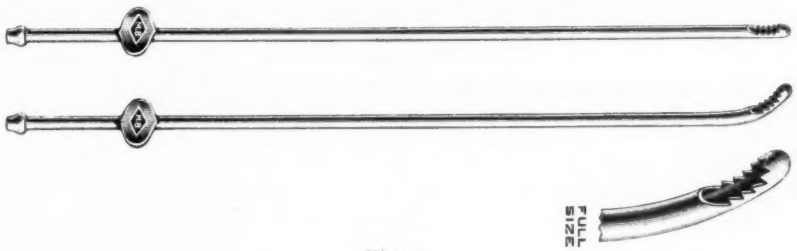

Fig. 1.

a sharply serrated cutting upper edge to the fenestrum, which is on the concavity of the curve near the open extremity. The cannula is about the diameter of the ordinary Rubin cannula for tubal insufflation, so that it easily slips into most cervices without previous dilatation. I need not go into the details of antiseptic cleanliness, which are clearly important. The proximal end of the cannula is attached by a very stiff tubing, sufficient to resist collapse from fairly strong negative pressure, to the bottle for collection of the curettings. This bottle, in turn, is connected with the suction apparatus, which can be either the simple water pump or the electric motor suction so generally used in operating rooms.

The suction is really a valuable adjuvant to the curettage, for loose particles of perhaps scanty curettings are thus not lost in the uterine cavity, being drawn into the bottle, or at least into the tubing. From the latter they will readily pass into the bottle, if, at the completion of the curettage but with the suction still on, the end of the curette is dipped for a few moments into sterile saline solution. This solution is better for this purpose than formalin, which may cake the particles

against the sides of the tube. In order to ensure good sections, the tissue should at once be transferred from the saline solution to the fixing fluid, usually formalin.

There are of course a minority of patients in whom curettage by this technic is not possible, at least without light anesthesia. Among these are the extremely nervous and apprehensive type, or those with very tiny cervical canals, or those with small, deep vaginal canals and inaccessible cervices. In multiparous women, the procedure is almost always easily possible. For that matter, where curettage is done in connection with other operative procedures requiring anesthesia, I have come to use the suction curette almost as a routine, for there is rarely any therapeutic need for dilatation, and the curettage can be just as thoroughly done by the suction curette as by the ordinary curette, which calls for preliminary dilatation. If one doubts the thoroughness of the curettage by this method, one can be readily convinced by following the suction curette by any of the ordinary uterine curettes. Usually no additional tissue is obtainable.

Suction curettage by the above-described technic is commonly accompanied by very little pain, though the occasional patient may complain considerably. The whole operation, however, rarely requires more than a minute or two, so that there are few patients who would not prefer this brief discomfort to the alternative of even light gas anesthesia and usually hospitalization. When possible, and this is usually the case, traction on the cervix with a tenaculum should be avoided, as this will cause pain through transmitted traction on the sensitive visceral peritoneum.

Following the operation, patients are allowed to rest for a short time, though practically all of them within a half-hour feel quite fit, so that they are taken home from the hospital or office in an automobile, with instructions to rest in bed for a day or two. I know of no theoretical risk in such a plan, and certainly there have been no unpleasant sequelae in any of the rather large series of patients whom I have treated in this semiambulatory way. To urge the plan as the routine form of diagnostic curettage would be absurd, for there are still many patients who, through their own preference or because of some reason in the surgeon's mind, should be curetted in the traditional and more deliberate fashion. But even a day or two in the hospital, plus operating room and anesthetic fees, constitute a not unimportant economic item to some patients, many of whom will be grateful if the desired information is obtained by simpler and less expensive means.

The dangers of suction curettage are those of curettage in general. Carelessness or the use of force in introducing this instrument, like the ordinary uterine curette, might result in perforation of the uterus. So far as I know, this accident has not occurred with the suction curette, though it has been used extensively in a number of clinics and by a

considerable number of gynecologists throughout the country. The method is not employed in the treatment of incomplete abortion, as the tissue masses often present in such cases would not pass through the cannula. It is in this group, in which the uterine wall is so often soft and unresisting, that the largest incidence of perforations is noted. Certainly, however, suction curettage should not be persisted in if there is any difficulty in introducing the cannula. Were perforations to occur with the suction curette, it is quite possible that the resulting damage to the intestine or other viscera might be much more serious than with the ordinary curette, because of the suction element. In the hands of the experienced gynecologist, however, it may be fairly said that the procedure is, in properly selected cases, almost devoid of danger.

What, then, are some of the indications for suction curettage, aside from the general considerations which have been enumerated? The chief ones may be enumerated as follows:

1. *To determine the nature of endocrinopathic menstrual disorders.* In many cases of amenorrhea, for example, the study of small particles of endometrium taken at intervals of a week or so, first from one area of the uterus, then from another, may show an atrophic undeveloped endometrium at all examinations, indicating an absence, or a marked deficiency, of the ovarian hormones responsible for endometrial development. In other cases of this disorder, one may find evidence of a definite histologic cycle quite similar to that seen in the normally menstruating woman, except for the absence of a bleeding phase. In abnormal bleeding with entirely normal pelvic organs, a very common finding is that of hyperplasia of the endometrium, which at once establishes the functional nature of the bleeding, with hyperestrinism as the underlying factor. On the other hand, hyperplasia may be found in cases of amenorrhea of even many months' duration, for, as is well known, amenorrhea may be due to persisting hyperestrinism ("polyhormonal amenorrhea"), with only occasional bleeding at long intervals because no drops in the estrin level occur.

In general, if an endometrium is well developed, it may be assumed that it is receiving an adequate supply of its selective growth hormone, estrin, and that the follicle-ripening gonadotropic hormone of the anterior lobe is also functioning normally. In the same way, if the endometrium shows definite secretory activity, there can be no question that it is being supplied with the corpus luteum hormone, progesterone, for no other hormone can produce this effect. For that matter, there is no other way, by blood or urine studies or otherwise, of determining this point. A progesterone effect in the endometrium presupposes a functioning luteinizing hormone of the anterior lobe.

2. *To determine the occurrence or nonoccurrence of ovulation in cases of sterility.* This, as a matter of fact, was the primary purpose for

which the suction curette I have described was devised. It is now well established that, in a small proportion of women, essentially normal menstruation may occur without ovulation. Cases of this anovulatory type are most frequent in the early and in the late years of menstrual life, though they are also at times encountered at other age periods. The practical importance of this observation, as I have emphasized in various papers, is in relation to certain cases of sterility which are not explainable by any other discoverable cause.

To determine this point, endometrial tissue is obtained, usually by complete suction curettage, just before the expected date of menstruation, when the endometrium normally presents the striking secretory changes produced under the influence of the corpus luteum hormone. If, instead of such a picture, the mucosa shows a clearly nonsecretory appearance—and this may be checked up by differential glycogen staining—it may be assumed that no progesterone is being produced, i.e., that there is no corpus luteum in the ovary and that the woman has not ovulated, at least during that particular cycle. If ovulation does not occur, pregnancy is obviously impossible. Such "ovulation" tests, therefore, performed usually by the suction curette, have become a part of the search for the causes of sterility, especially when other studies, such as basal metabolism determination, tubal insufflation, examination of the husband, etc., have thrown no light on the problem.

3. *Diagnosis of pathologic lesions.* This is particularly important in the differentiation of causes of uterine bleeding. I have already spoken of the frequency with which, in cases of intrauterine bleeding in women with normal pelvic organs, the endometrium yields the typical hyperplasia which establishes the endocrinopathic nature of the bleeding. On the other hand, much more serious lesions may be revealed. In two of our cases, unsuspected tuberculosis of the endometrium was disclosed, subsequent operations confirming the presence of the disease, not only in the uterus, but also in the tubes. Again, in a number of cases of postmenopausal bleeding, suction curettage has shown definite adenocarcinoma. In suitable cases of postmenopausal bleeding, a plan which I often follow is to do a preliminary suction curettage without anesthesia, followed by microscopic examination of frozen sections if the tissue is sufficiently abundant or suspicious, proceeding at once with the radical operation if adenocarcinoma is revealed.

4. *Occasional therapeutic value.* As with ordinary curettage, functional bleeding may be cured by suction curettage. On the other hand, in the majority of cases, functional bleeding occurs after a variable length of time. In young women, where radiotherapy is undesirable, such recurrent and frequent profuse bleeding often constitutes a trying problem, especially if, as is frequently the case, organotherapy is found to be unsuccessful. In many of these cases, a repetition of the curettage at intervals often will be preferable to radiotherapy or other rad-

ical measures. In at least some cases, this can be done by the suction curette, thus avoiding the necessity of repeated hospitalization. In cases of functional bleeding, a readjustment of endocrine balance occurs after a stormy bleeding career of varying length, and the repetition of suction curettage, with the temporary cessation of bleeding which it practically always brings about, will help the gynecologist to tide patients over this period of endocrine upset until the hoped-for readjustment occurs.

CONCLUSIONS

The suction curette is of frequent value in the study of both functional and anatomic gynecologic conditions. It is usually possible, and often a real advantage, to employ it without anesthesia and without hospitalization. This method of curettage is not feasible or advisable in all cases, and the traditional operation of "D & C" is still preferable, or necessary, in a considerable group. But the field of usefulness of the instrument is a rather wide one, and one which many gynecologists have overlooked.

MASSIVE CONGENITAL FIBROMATOSED PIGMENTED MOLE OF SCALP*

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IT IS surprising how frequently physicians allow patients to go for years with lesions which are not only cumbersome to the patient, but also quite distressing for themselves and others to see. Still such is the case, and we occasionally have the opportunity of seeing interesting lesions which present some interesting problems in their treatment.

In August, 1927, I had the opportunity of seeing a young man, twenty-two years of age, who had a large tumor on the scalp which he had had all his life (Fig. 1). It had slowly increased in size and thickness, and he had consulted many physicians and surgeons in various cities and clinics. Radium was used by one without any effect whatsoever. Other surgeons had taken x-rays of the scalp and advised against operation, stating that they thought surgical removal would be impossible and dangerous. This deformity, which necessitated the continuous wearing of a cap while at work to cover the ugly growth, was a constant source of unhappiness to him through college and a tremendous handicap to his professional advancement in journalism.

Upon examination it was found that there was a hard, firm growth of the scalp, extending from the right forehead backward to the occiput, and from the midline down to the ear and the mastoid region. Its surface was convoluted, and here and there were some hairs growing from its surface. It was not a compressible growth, and it seemed to move with the scalp and not to be connected with the underlying pericranium. We, therefore, urgently advised the young man to have the lesion removed by surgical excision. He was operated upon at the Lenox Hill Hospital in October, 1927.

The operation was performed under colonic ether oil anesthesia. The incision was made through the scalp, allowing about one-fourth inch margin from the edge of the tumor, after the circumference of the tumor had been injected with 1:10,000 adrenalin solution for better hemostasis. The incision was carried down to the pericranium, and a plane of cleavage was entered between the lesion and the scalp, permitting a quick and safe removal of the entire growth with very little accompanying hemorrhage (Figs. 2 and 3).

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The large defect of the scalp was then immediately covered by cutting long and wide Thiersch skin grafts from the thigh. It was possible to cover this large defect with only three pieces of Thiersch

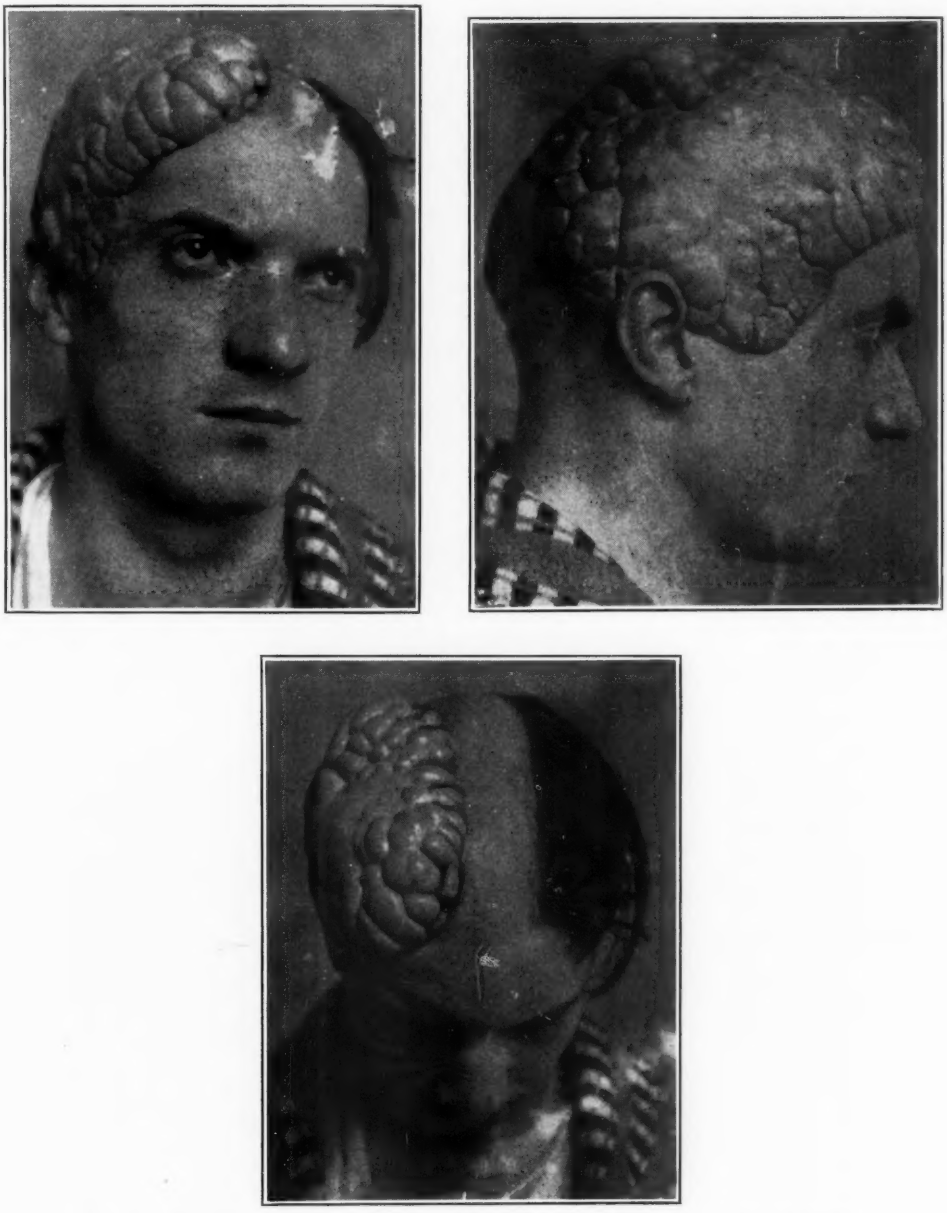

Fig. 1.—Showing massive congenital fibromatosed pigmented mole of scalp.

grafts. The edges of the graft were not completely brought up to the margin of the scalp but only close to the margin of the scalp, leaving an interval of about one-eighth inch. This interval is important, as it allows the scalp to grow down to the Thiersch graft, rather than the

Thiersch graft to heal up to the edge of the scalp. If the epithelium of the scalp grows down to the Thiersch graft, a flat, smooth wound

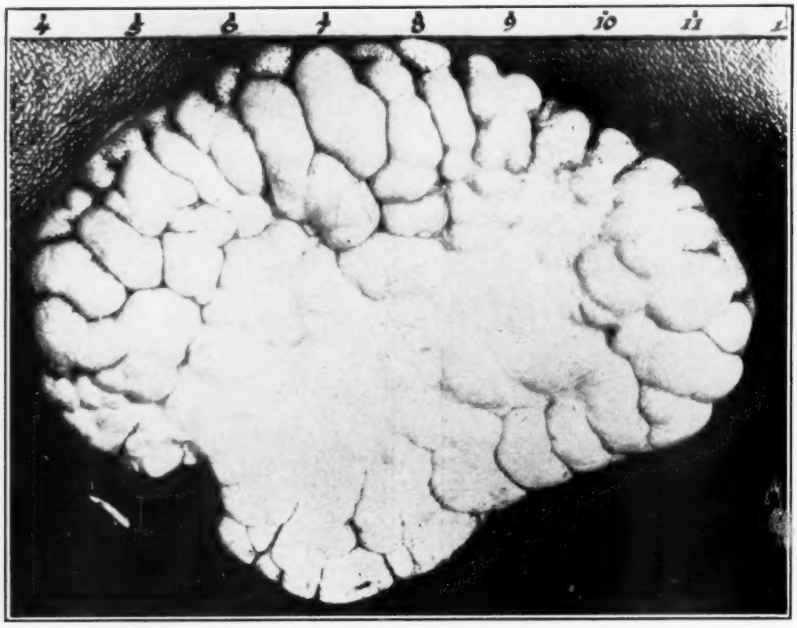

Fig. 2.—Shows outer surface of tumor after removal.

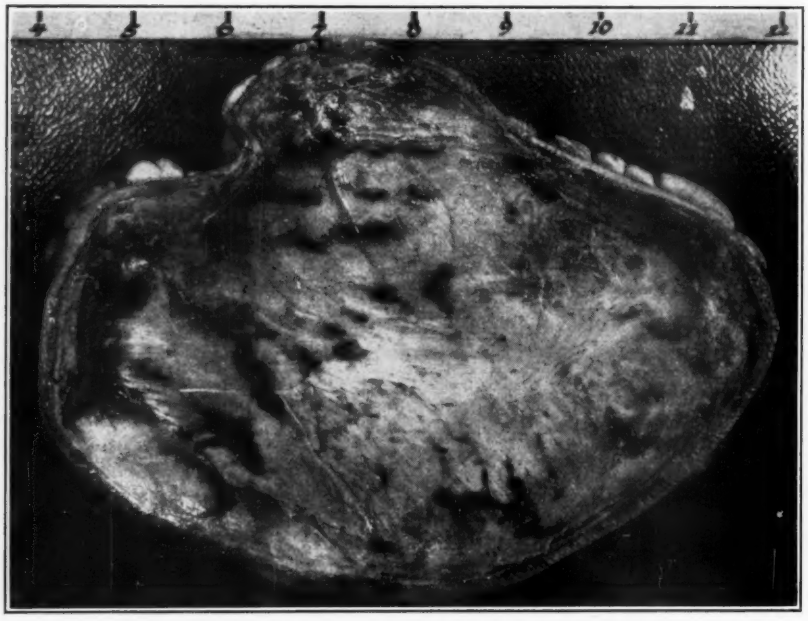

Fig. 3.—Shows inner surface of tumor after removal.

edge is obtained, while a graft placed up to the edge of the scalp gives immediate healing, but there will be a sharp, raised margin to the

wound. The raw surface between the Thiersch graft and the scalp was covered with a strip of iodoform gauze, well washed out and dried between gauze compresses to rid it of the excess moisture. The Thiersch grafts over these large areas were covered with plain sterile gauze and no silver foil. (We have given up the use of the silver foil over the grafts, as it does not seem necessary and occasionally gives an ugly dark silver stain to the graft.) The most important part of the dressing of the graft is the application of sterile adhesive strips which must be placed in every direction to counteract any stress or pull and to prevent any displacement whatsoever of the graft. The whole surface of the dressing must be covered with interlocking strips of adhesive. Following this, a compression dressing is applied.

The area on the thigh from which the Thiersch graft was taken was covered with twelve to fourteen layers of silver foil covered by gauze and adhesive strapping. This dressing of the thigh must be left in place for two weeks when it may be removed and the area usually is completely healed.

The patient made an uneventful recovery. On the sixth day the first dressing was done, and it was found that the Thiersch graft had taken successfully. A small strip of gauze with one per cent fuchsin ointment was then placed along the edge, and it took about two weeks for the scalp to grow down to the edge of the graft (Figs. 4 and 5). As soon as the grafts had completely healed, he began to wear a partial wig fastened on to the scalp with the typical wig adhesive. From a distance it is not easy to see that the patient is wearing a wig over half of his head. He returned to his work a healthier and certainly a happier man. It is now nine years since the operation, and there has been no recurrence (Figs. 6 and 7).

The pathologic examination of the specimen showed that it was a congenital fibromatosed pigmented nevus of the scalp. It measured 20 by 15 by 8 cm. The skin over most of the growth was thin and loose, but the deeper structures were very hard. The edges of the tumor faded off into normal scalp tissue. On cutting through the growth, a gritty sensation was experienced, and the cut surface revealed a dense, white, fibrous tissue with areas of calcification.

Microscopically, examination showed skin and subcutaneous tissue to which was attached a small amount of voluntary muscle. The surface of the skin was convoluted, and the epidermis appeared to be intact, though varying in thickness in different parts, being thinned out in places, and hypertrophic in other places. The dermis and subcutaneous tissue showed marked overgrowth of fibrous tissue which had largely replaced the fat of the latter tissue. The fibrous tissue was for the most part very dense and composed of compact bundles of fibrils and relatively few small compressed spindle cells. This tis-

Fig. 4.—Anterior view with healed Thiersch grafts on scalp.

Fig. 5.—Lateral view four weeks after operation showing healed Thiersch grafts in place.

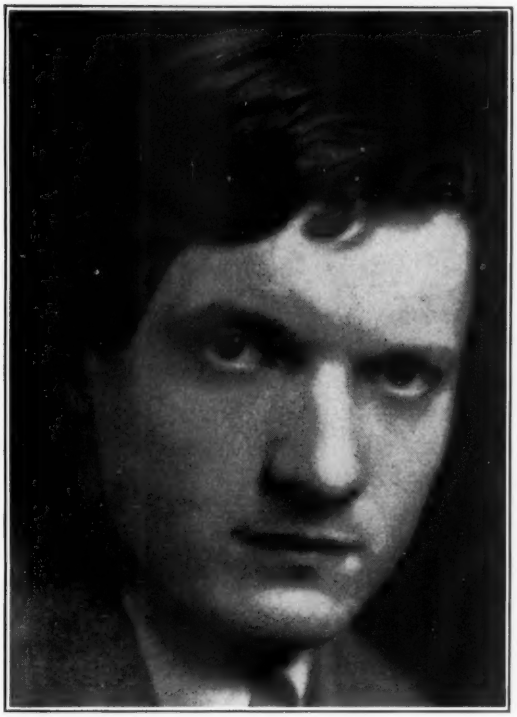

Fig. 6.—Anterior view one year after operation. With wig.

Fig. 7.—Lateral view one year after operation. With wig.

sue showed continuous hyaline degeneration. Embedded in the deeper parts was an island of compact bone. Scattered through the tissue and most abundant in the outer part were nests, vertical strands, and irregular masses of atrophic nevus cells, a few of which contained yellowish brown and blackish pigmented granules. Most of the hair follicles and sebaceous glands had disappeared, and the persistent ones showed varying degrees of atrophy. There was no evidence of malignancy.

CONCLUSION

This was a congenital benign tumor of the scalp in a young man, twenty-two years of age, who had sought relief of this deformity for many years. There is no question but that an earlier operation performed along the same lines as the one reported would have relieved this patient of a great deal of mental worry and unhappiness. It behooves surgeons to urge early operation for such lesions.

LA METTRIE

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"La Mettrie . . . cet fut un philosophe, sans cesser d'être un médicin."
—De Vizeaux.

THE number of medical men who may be counted in the world's group of creative philosophers has been relatively small. It is not that the average physician does not philosophize, for the very nature of his calling continually compels him to build up a ready-made metaphysics, a protective "defense mechanism," as it were, which will enable him to believe or disbelieve in his own medicines and in their respective values. One would think that doctors would attempt to go further and seek a correlation between life and death, the two commodities with which they constantly deal. But this has not been the case. Undoubtedly many have tried to do so, but, for one reason or another, have wandered off into literature, politics, and art. A limited few, however, have succeeded in remaining faithful to their profession and, in addition to becoming outstanding investigators in anatomy and physiology, have sought to combine in some fashion or another the spiritual and physical components of man. Maimonides, Bacon, and Avicenna were three such individuals of the Middle Ages; William James is one of our own times. A study of the philosophers of the eighteenth century will reveal two of this group who stood out as pioneers, the English chirurgeon, John Locke, and Julien de la Mettrie, the Father of Materialism.

The Frenchman, a weird mingling of many emotions and ideas, an individual who was "no small cypher in the ranks of the Asclepiadae," attempted single-handed to change the prevalent religious and philosophical ideas of his age. The Breton was brave enough to express his ideas forcefully, and, it must be admitted, quite tactlessly, and soon aroused the jealously of his professional confreres and the wrath of those in high places. The results of his hopeless struggle were what might be expected, and, indeed, the terse epigram of Epicurus, "It was to philosophy that I owe my worldly ruin and my soul's prosperity," had no better example than La Mettrie's life.

Men have been affected to a greater or less degree, one way or another, by their parents' wishes and station in life, by their early

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religious training, and by the age and generation of the world into which they were born. All of these factors had a great influence in the life of the doctor-philosopher.

The famous materialist was born in St. Malo, a town later to give Chateaubriand to the world, on Christmas Day, 1709, six scant years before the death of Louis XIV. His family has been described as "noble but poor and impoverished," and for financial reasons they had been compelled to enter trade. In the days of the Golden Emperor, such a move was practically tantamount to social suicide and undoubtedly the La Mettries received many sneers and slights from their more fortunate aristocratic brethren. Such conditions would tend to develop much ready-made materialism.

The time came shortly to consider the matter of a formal education. Already the young lad was a facile talker, and hopes were entertained by his parents that their son would enter the church. A malicious historian has said that Julien's verbiage was the principal reason for their pious wish. To this end, the growing boy was sent first to the school of Coutances, where he soon won prizes in rhetoric. Thence he proceeded to Plessis in Paris to study logic, and it was here that the youth came under the magnetic spell of one of the professors, Cordier, a nationally known Jansenist. A few words in passing may be necessary to explain the ideas and tenets of this intense, fanatical, religious sect. Briefly stated, this group brought the principles of St. Augustine up to the eighteenth century. They stated that a belief in the helplessness of man and his utter dependence on his Maker were ever necessary. They argued that no amount of church going and ceremonial could save man, and the group rejected justification by faith as impossible and declared that while conversion might be instantaneous it was only the beginning of a long and gradual process. Nevertheless, their religious leaders held that a personal relationship of the human soul to God existed and that mediation could only be gotten through the Roman Catholic Church.

The pliable mind of the serious lad, influenced by this strong, forceful teacher, was much impressed by such reasoning.

From Plessis the young student went to Harcourt for a course of "natural philosophy." It was about this time that La Mettrie began to turn back from his ideas of becoming a priest, and as Frederick the Great has so aptly stated, "On persuada le père, on l'assura que les remèdes d'un médicin médiocre rapparteraient plus que les absolutions d'un bonne prêtre."

And so from the priesthood, the Breton turned to medicine. In this step he was undoubtedly influenced by Hunauld, the village physician, whom La Mettrie greatly admired and respected. Specific training, more than one would get by attending the daily rounds of a small town practice, was thought advisable. Consequently,

La Mettrie, doubtless on the advice of his friend, went off to the medical school at Reims,* which was one of the best in the century. Here in 1728, the ex-theological student obtained his "bonnet de docteur." He was now nineteen years of age, still too young to practice, and, as was the fashion of his day, the young doctor proceeded to Leyden, the University of the great Boerhaave, then the leading medical man of the world. Indeed, his fame was so great that letters addressed "Boerhaave, Europe" would always reach him. The Dutchman was

Fig. 1.—Reproduction of likeness of La Mettrie, taken from Quépat's work by Helene Somers Millar.

an authority on many things and, curiously enough, among his many accomplishments, prided himself on being a critic of Spinoza and Hobbes.† And so while the great educator poured chemistry, botany, and "practical medicine" into students who attended his lectures, he

*It was about this time that several American Colonials attended the University. The most famous was John Jones, author of the first surgical manual written in America.

†Boerhaave had actually received his doctorate for his dissertation "De Distinctione Mentis a Corpore," in which he openly opposed the doctrines of Epicurus, Hobbes, and Spinoza.

undoubtedly found time to explain the subtleties of pantheism and materialism as expounded in "The Ethics," "De Corpore," and "Leviathan" to a few of his favorite disciples.

But there comes a time when theory must give place to actuality, especially when a young man must think of food, and when one's parents become fatigued and wearied of providing tuition and "running expenses" for peripatetic collegians. Back to St. Malo came the twenty-four-year-old physician full of ideas, with one of the best theoretical professional educations possible for his time, to plunge into the sorrows and griefs of a general practice. But the ex-student's mind lingered with the academic, and he had no desire to lapse into marmoreal dullness. He found time to translate Boerhaave and, with the bland egotism of youth, even to compose a brochure on practical medicine. Hunauld died shortly after his assistant returned. Instead of settling down and building up a safe and lucrative practice, as any unimaginative man would have been glad to do, the ambitious La Mettrie suddenly, after three years in the tiny village, gave up his place and set off for Paris. In this city, the country doctor apparently had enough influence to secure a commission as medical officer with the French Guards, chiefly, it would seem, through the benevolence of Morand, the surgeon to the Invalides, and the Duc de Grammont. Most nonmedical historians have called La Mettrie a military surgeon. This he apparently was not, in the strictest sense of the word, for, as Bonnette has pointed out, the few regiments of the time who possessed medical assistants had no less than three varieties, doctors or medical officers, chirurgeons, and apothecaries, and these all had sharply defined duties and professed great contempt for anyone who was not of their own narrow professional sphere.

La Mettrie was in the prime of his life when the Silesian Wars between Maria Theresa and France began, and his regiment was moved to the East. The Army soon saw active service. As a medical officer, he participated in the battle of Fontenoy under Marshall Saxe.* In this fight, one of the outstanding points of the combat was the charge of the Guards Brigade against the Gardes Français. Whether or not, as the story goes, the polite Frenchmen really asked the opposite side to fire first may well be disputed. The casualties of this bloody encounter were tremendous. Fifty officers and 760 men of the first regiment fell, and the losses of the other troops were equally severe. Among the dead was La Mettrie's Colonel and benefactor, Grammont.

Action was seen again in Dettingen, and the Médicin was also present at the siege of Freiburg, where the young officer was stricken with a severe fever. During his convalescence, the sick man began to think about the soul, about life and their causal relations—ideas which were

*The famous general at that time was suffering from a dropsy so severe that he was unable to ride a horse and was confined to a wheel chair!

soon to find formal expression in his books. Not that he had not been engaged in practical research before this, for it would seem from all accounts that he was anything but an armchair researcher! Several anecdotes have been told about his investigations. Once, indeed, the grooms of his regiment assaulted their medical officer and beat him severely. In fact, they almost killed the Breton before he was rescued, so much did these servants resent his guinea pig technic on their associates and on themselves. Still the medical officer's work for his superiors was satisfactory, for, even if his inferiors hated and feared him, he was in due time promoted and given the responsible position as chief to several base hospitals which were located in Flanders and the Low Countries.

La Mettrie was one of those individuals who needs must write, but with his pen he almost always seemed to succeed in creating trouble for himself. One of the first of the young author's works, written in St. Malo, was his *Observations de Médicine pratique*, which was followed in 1735 by a translation of Boerhaave's *L'Aphrodisiacus*, to which he added a few comments and observations of his own on the nature of venereal diseases. A year later, Astruc, of Paris, published his *De Morbus Venereis*, in which he spoke appreciatively of the work of the young medical man, but also called attention to several errors of translation that had been made. In 1737, the Breton's *Traite du Vertige* appeared, and, in 1739, his *Nouveau Traite des Maladies Veneriennes* appeared. Astruc still took occasion to "sharpshoot" and criticize the works of his rival. Rapidly numerous lampoons and satirical papers appeared throughout France which were insultingly frank and which seared with the branding iron of caricature. Many of these were purported to come from La Mettrie, and some of them doubtless did. In them the entire Parisian medical profession was ridiculed to high heavens. Almost no one was spared, least of all Astruc.

This war of pen and pamphlets was stopped perforce for a period when the Guards moved off to war. But once the Frenchman was back to barrack life, his urge to write seized him again. It was soon after his appointment as Medical Chief of half a dozen hospitals that the army officer really drew fire from almost everyone. This time not only were the medicos opposed to him for the very obvious insults leveled at them, but in a very short time the Roman Catholic Church, the several Protestant faiths, and the French Throne rose against this defiant author. The reason—principally—his *Natural History of the Soul*, which was shortly followed by other books of even more materialistic and apparently more atheistic persuasion. At any rate, all of them aroused tremendous bitterness and feeling against their creator.

These volumes were immediately condemned; first by the army chaplains, and then by the high church authorities in the *Index Expurgationes*. So much pressure was brought to bear on La Mettrie that he

was forced to resign from the Army and flee to Leyden. Even here he was not safe. Again at night, on foot, and in secrecy, the hunted author was obliged to leave this city. The brilliant, caustic man was at the end of his resources until his compatriot Maupertuis took occasion to speak to Frederick the Great about him, and the soldier-philosopher was formally invited to come to Berlin. This the outcast was happy to do and, in 1748, was personally received by the cordial King who immediately made him a reader and pensioned him with enough money for his immediate needs. Once more there was time to write, and directly there appeared the *Memoire sur la Dyssentérie* and the *Système d'Épicure*. No longer hunted from pillar to post, he had time for leisurely conversation and banter with the court savants, d'Argens, d'Algarottis, and Voltaire among others. With the last individual, little love was lost. Probably each one was jealous of the other's supposed influence with the Emperor.

But all was not satisfactory in Berlin. We have Voltaire's word that La Mettrie had asked him to intercede with the Parisian authorities on his behalf. The author of *Man a Machine* was human enough to be homesick and, with a sentimentality quite unnecessary in a true materialist, continually longed for his native land.

Just what is the essence of his philosophical works? Today we get no spinal thrills at his ideas, as they are openly accepted, or at least tolerated, by the majority of our generation. But they were diametrically opposite to the harsh, metallic minds and the generally accepted ideas of his day. For an illustration of the power and mentality of the Catholic church of that century, two cases may be cited:

As late as 1748, a woman in France was fined 3,000 francs because she dared to employ a Protestant midwife. Again, in Toulouse, no one who was not a member of the Catholic church could be a lawyer, physician, apothecary, printer, bookseller, or grocer. So much for the narrowness of the time, though it must be admitted that it was not unlike certain contemporary countries of today. It was HERESY spelled in capital letters to have a man "prove" to his own satisfaction, at least, and in print where all might see and read, the fact that "nature was amoral," as well as to state loudly, "Why should one believe in a providential nature? We have not one proof; the greatest chance favors the contrary opinion." Authors of such ideas were dangerous to State and Church, and they should be immediately and completely destroyed and uprooted. So argued those who wore the royal crowns and cardinal caps. But La Mettrie was first a true "doctor of observation," and, although for this trait he openly acknowledges his debt to Boerhaave, he had the courage to go on and to take up Cartesian materialism and apply it without qualification to the human body.

La Mettrie picked up mechanism, as Durant writes, "Where the frightened Descartes like a boy who has burned his fingers had dropped it, and announced boldly that all the world not excepting man was a machine."

F. A. Lange declares that La Mettrie was one of the most abused and least read men in the history of literature and called him the "scapegoat of French materialism in the 18th Century." As Frederick the Great has said, the priests insisted on finding "seeds of heresy in a work dealing with physics."

Given the hypothesis that the so-called higher activities, that is, the soul, the memory, the passions, and feeling, are of mechanical and materialistic origin, then man becomes a machine and "self love is a virtue, crime a disease." The soul is merely the thinking part of the body, and, at death, it, too, passes away. The soul may therefore become diseased. For examples of this, we have the case of the paralytic who asks if his leg is still in bed with him, of the soldier who thinks that he still has his amputated arm. Mental twists are described; people who believe that they are werewolves, cocks, vampires, "and the man who maintains that his nose is of glass and who has a continuous compulsion to sleep on hay in order that his proboscis may not be smashed." Other changes follow circulation if it be too fast, and one should remember that a good meal and drink have well-known effects on the soul. Again, raw meat, which "makes animals fierce" and which would have the same effect on men, is mentioned for its effect on the passions. This is so true that "English who eat meat red and bloody and not as well done as ours seem to share more or less in the savagery due to this kind of food and to other causes which can be rendered ineffective by education only . . ."

The transition from animals to men is not violent, as true philosophers will admit. If those who are born deaf can be taught, why cannot the ape? La Mettrie goes further. He favors frank atheism, for the Frenchman believes that the existence of God has been unproved and is practically nonimportant for our existence. Argument from design becomes ineffective against the hypothesis of mechanical casuality. "Man is so complicated a machine that it is impossible to get a clear idea of the machine beforehand and hence impossible to define it."

After an examination of life the philosopher is perforce limited to the one thing about which it is possible to know, that is, the human body.

The physiology of the eighteenth century was sketchy, to say the least. Briefly speaking, the circulation of the blood was known, but respiration was ignored, and the functions of the nervous system were

only touched by all physicians, if at all, in an extremely rudimentary fashion. It was held that "animal spirits" animate the "nerves, more or less fluid, more or less rapidly." Of the genital systems, scarcely anything was known save the fact that the union of the sperm with the egg would cause conception. La Mettrie wished to correct ignorance among his professional brethren, and stressed the need for autopsies and skill in pathologic anatomy. The old pupil of Boerhaave guessed at the origin of nerves and argued that each nerve carries "impressions" to a special region of the nerve center. "The brain has its muscles for thinking as the legs muscles for walking." The Frenchman knew that irritation of the optic nerve gave symptoms of light. Drugs were discussed with their effects on the human mind: opium which paralyzed wishes and stimulated the imagination, coffee which excited and animated conversation, and the value of good food and wine on a drooping spirit. The Breton worried about gastric fermentation and of it said, "No air, no fermentation." The various effects of climate are mentioned. The idea of irritability has been generally credited to Haller's *Eléments de physiologie* (1761), but in *L'Homme Machine,* we find that:

"Life principle does not find in the soul the material consciousness; this is not in the whole but in the separate part and each fiber is stirred by it." Ten examples are given to prove this contention but space will permit but four to be mentioned here: (a) The flesh of animals continues to palpitate after death, e.g., tortoises and lizards. (b) Muscles separated from the body will contract when excited. (c) Injections of warm water will resuscitate the heat in the muscles, according to Cowper. (d) The heart of a frog will move one hour after separation from the body. . . .

A hint at evolution is made by this amazing writer, but even more interesting is the explanation for epidemics which he said are caused by "seeds" which "come from the air." The work of Leeuwenhoek is cited, and the boiling of water is recommended as an excellent means of purifying water. This was over one hundred years before Pasteur's work was published.

Personally La Mettrie was not a gentleman with a cream puff soul. The philosopher is described as "un homme vigoureaux," an individual who always seemed to be laughing, his enemies declared sneering, and it was with this ever quizzical, and often sardonic, countenance that this dauntless hedonist faced an intolerant, reproving world. During the greater part of his life, except for a few bad months when he had been compelled to leave Leyden, the Frenchman had enjoyed a glorious, carefree existence. Doubtless a sexual virtuoso in keeping with the fashionable men of his day, undoubtedly a gourmet of the

first magnitude, and a gay devil who frankly liked his leisure, La Mettrie would be found every afternoon sprawled half-dressed on his couch, wholly at ease and always ready for any form of cultivated lechery that might suggest itself. An acknowledged libertine and rake, who though married to Louise Charlotte Dreano, by whom he had at least one legitimate child, he was known to have at least one "fille de joie" in Berlin whom Frederick the Great actually pensioned upon her lover's death.

It was an ironical twist of fate that two of the things of which he was really passionately fond, the practice of medicine and his gastronomic athletics, were to be the immediate causes and reasons for his death. The accounts of the final illness vary somewhat in detail, but it would seem that La Mettrie, on a bet, gulped down an entire pheasant pastry pie, after a many course banquet at the house of MiLord Tyrconnel, the English ambassador at Berlin. Shortly after this awe-inspiring feat, the King's Reader was seized with what appeared to be botulism, an outcome not surprising when one reads a description of this "snack of pastry," for it was made of "eagle disguised as pheasant, which had arrived from the North, with plenty of bad lard, pork hash, and ginger in it. . . ."* At any rate, the attending German physicians advised purges. To this the sick man violently disagreed. "Bloodletting was the procedure of choice here," he gasped between cramps, and ordered repeated venesections. Reluctantly they complied with his wishes, and the Frenchman was bled no less than eight times.

At the moment of death, an Irish priest, a Father MacMahon, chaplain of the Ambassador, desired to convert La Mettrie and elbowed his way into the death room. The dying man would have nothing to do with him, but the Father persisted in sitting down and waited expectantly by his bedside. To quote Carlyle again: "La Mettrie in a twinge of agony cried out, 'Jésus Marie!' 'Ah, vous voilà enfin retourné à ces noms consolateurs,' exclaimed the Irishman. To which La Mettrie answered, in polite language, to the effect 'Bother you!' and expired a few minutes after. . . ."

Before his death, the philosopher had requested that he be buried in the garden of the Ambassador's grounds, but this wish for unhallowed ground was not respected, and the bloated body was carried into a Catholic church. The priests had beaten him in the end!

Frederick the Great gave the eulogy before the Berlin Academy, and his speech has been preserved to the present time. It is the usual type of panegyric and is, in many respects, like the annual Elk Club requiem given in our small American towns of today, the kind of stuff that nobody, not even the orator, bothers to take very seriously. But

*Thomas Carlyle's translation of Voltaire's letter to Madame Denis.

in a letter to Wilhelmina, the same month of his reader's death, November, 1751, the Emperor writes, little expecting that it would ever be compared with his formal speech:

"He (La Mettrie) was a good doctor and a very bad author; by avoiding to read his books one could manage to be well content with himself!"

The author wishes to thank Helene Somers Millar for her reproduction of La Mettrie taken from Quépat's work.

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(a) L'Homme Machine, with its dedication to Haller
(b) Traité de L'Ame
(c) Abrege des Systemes
(d) L'Homme plus que Machines
(e) Les Animaux plus que Machines
(f) Systemes D'Epicure

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Editorials

Surgical Complications of Amebiasis

AMEBIASIS is likely to be considered by most physicians as a condition which occurs principally in tropical or subtropical localities and which is of little surgical interest. That the former concept is incorrect is borne out by the fact that since the Chicago epidemic, which probably only served to make the profession "amebic conscious," amebiasis is being detected in many of the northern, eastern, and western localities of the United States. In a series of 49,336 persons examined in all parts of the United States and collected by Craig,[1] 5,720 (11.6 per cent) were found to be infected with endamebic histolytica. Craig[2] found in examining 189 physicians from all parts of the United States *E. histolytica* in 12.7 per cent. Unquestionably amebiasis occurs ubiquitously. That amebiasis is of surgical importance is attested by the fact that surgical complications occur not infrequently.

Surgical complications of amebiasis are more likely to occur in the absence of dysentery than in the cases in which this clinical manifestation is present. A probable explanation for this fact is that when manifested by dysentery the amebic infection is more likely to be recognized by the clinician and adequate therapy instituted before the development of the surgical complications; whereas in those cases in which dysentery is absent, the underlying lesion of the bowel is likely to be overlooked, because the complicating lesion produces the clinical manifestations.

Probably one of the most frequent surgical complications of amebiasis is amebic appendicitis, which may occur as an acute suppurative or a chronic inflammatory process. In both instances, the true nature of the lesion is likely to be overlooked unless the physician considers the possibility of its existence. This is particularly true in the low grade chronic infections, and unless careful examination of the feces is made, the true nature of the condition is missed. The frequency of the acute amebic inflammatory processes in the appendix is demonstrated by the investigations of Clark,[3] Strong,[4] and Craig,[5] who obtained 7 per cent, 40 per cent, and 16 per cent incidences, respectively, of suppurative appendicitis in fatal cases of amebiasis. Although the incidence of the subacute and chronic inflammations of the vermiform appendix produced by the *E. histolytica* is more difficult to determine than that of the acute inflammations, it probably occurs much more frequently than is generally considered. So frequently does this condition exist that it is the rule in the author's clinic to have a careful stool examination for

E. histolytica in all patients in whom a diagnosis of chronic appendicitis is made. Probably the appendiceal infection is only a part of a more or less generalized involvement of the intestinal tract. In approximately 10 per cent of these cases, the parasite is found; and in most of these instances, antiamebic therapy is sufficient to bring about a relief of all symptoms and signs.

The second most frequent surgical complication of amebiasis is hepatic abscess, which results from the invasion of the liver following the transportation of amebas to it through the portal vein. The relative frequency of this complication is shown in an analysis presented by Ochsner and DeBakey[6, 7] in 1935. During the period 1928 to 1933 inclusive, there were 574 patients diagnosed as having liver disease in the Charity Hospital in New Orleans, of which 14.6 per cent had liver abscesses and 10.2 per cent had amebic abscesses. Amebic involvement of the liver occurred much more frequently than these figures indicate, because those cases with amebiasis which responded to amebicides without destruction of liver tissue had amebic hepatitis without suppuration. In a series of 4,392 collected fatal cases of amebiasis, 37.9 per cent were complicated by hepatic suppuration; and in the Charity Hospital cases, amebic abscess complicated amebic dysentery in 15.2 per cent. Of 102 cases of liver abscess admitted to the Charity Hospital and the Touro Infirmary during this period of time, 73 (71.5 per cent) were amebic abscesses and 29 (28.4 per cent) were pyogenic. The fact that amebic suppuration of the liver can occur without an antecedent diarrhea is demonstrated by the findings in the above mentioned series in which a positive history of previous diarrhea was obtained in only 59.6 per cent, and in which diarrhea was a symptom at the time of admittance to the hospital in only 19 per cent. As mentioned above, the probable reason for the high incidence of amebic hepatic suppuration in the absence of diarrhea is that the original amebic infection of the bowel is overlooked and not treated, which permits the amebas to gain entrance to the liver through the portal system. Probably in such cases the amebic infection is limited to the right side of the colon, the left side being uninvolved so that there is absorption of the increased intestinal secretions from the diseased right bowel.

Typically a patient with amebic hepatic suppuration complains of pain in the right upper quadrant of the abdomen, has a moderate degree of fever, and almost always has an enlargement of the liver. The laboratory examination is quite characteristic in that there is moderate leucocytosis without a proportionate increase in the polymorphonuclear leucocytes as is seen in pyogenic infections. Of greatest value is the x-ray examination which, as demonstrated by Granger,[8] shows in uncomplicated liver abscess a bulging of the diaphragm, and a pointing upward into the lower lung field. Whenever there is associated involvement of the subphrenic space, there is obliteration of the cardiophrenic angle in

the anteroposterior roentgenogram and obliteration of the anterior costophrenic angle in the lateral view. In contradistinction to these findings, obliteration of the lateral costophrenic angle in the anteroposterior roentgenogram and the posterior costophrenic angle in the lateral view is indicative of subphrenic abscess not associated with amebic suppuration.

Treatment of uncomplicated amebic hepatic suppuration consists of simple aspiration combined with the use of amebicides. Open drainage is to be condemned except in the presence of secondary infection, because as in an uninfected tuberculous abscess, open drainage is always followed by secondary infection with its disastrous results. The soundness of this contention is substantiated by the results obtained in a series of 4,035 cases collected from the literature in which, following an open operation, there was a mortality rate of 47.2 per cent; whereas in a series of 459 cases in which the conservative treatment was used, the mortality rate was 6.9 per cent. In Ochsner and DeBakey's[6, 7] series of cases, the open operation in 46 cases was attended with a 19.5 per cent mortality; whereas in 24 cases in which the conservative treatment was used, the mortality rate was 4.1 per cent. In cases in which secondary infection has already occurred as determined by culture and examination of the aspirated pus, open drainage is indicated and desirable. These cases are extremely rare, however, as secondary infection is usually the result of the entrance of microorganisms *following open* drainage.

Another complication of amebiasis, although frequently not considered, is pleuropulmonary involvement. In the 59 cases studied by Ochsner and DeBakey,[7] 7 (13.5 per cent) were uncomplicated by extension to the pleura or lung. In reported series of 2,490 hepatic abscesses, pleural complications occurred in 7.5 per cent and pulmonary complications in 8.3 per cent. In the series from the Charity Hospital and Touro Infirmary, 10.5 per cent of the hepatic abscesses were attended by pulmonary complications and 5.2 per cent by pleural complications. Pleuropulmonary complications are manifest by cough and expectoration, which were present in 95.2 per cent of Ochsner's cases. Other manifestations are fever, thoracic pain, right upper abdominal pain, diarrhea. The expectoration of "chocolate-sauce" pus is almost pathognomonic of the condition and always indicates a bronchohepatic fistula.

As in amebic infections of the liver, conservative treatment in pleuropulmonary complications, particularly the pulmonary ones, is important. In a group of cases collected by Ochsner and DeBakey,[7] the mortality rate in those cases in which amebicides alone were used was 5.4 per cent. In those cases in which the patient was operated upon and emetine used, the mortality rate was 16.6 per cent; whereas in those cases in which open drainage alone was used, the mortality rate was 48.2 per cent. In cases, however, in which an amebic abscess of the liver has ruptured into

the pleural cavity, evacuation must be obtained by aspiration. In those cases, however, in which there is a communication between the hepatic abscess and the bronchus, strict conservatism is preferable.

Occasionally a hyperplastic form of amebiasis involves the cecum and is of importance, particularly in elderly individuals, because of the difficulty in differentiating it from malignancies in this region. Ochsner has seen several cases in which such differentiation was impossible until after exploration of the lesion. In every such instance careful examination of the stool should be made for *E. histolytica* and amebicides should be used before attempted extirpation of the involved segment of bowel, because in such instances the lesion is not limited to the hyperplastic portion of the bowel.

That amebiasis can be complicated by pseudopolyposis of the colon is attested by a recent report of Anderson et al.,[9] in which following a prolonged amebic infection there resulted a pseudopolyposis of the entire colon. This patient recovered following a two-stage extirpation of the colon.

In all cases with vague gastrointestinal disturbances, irrespective of the locality, the possibility of amebiasis should be considered because frequently a needless and at times dangerous surgical procedure can be prevented.

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—*Alton Ochsner.*

Preoperative and Postoperative Care

TO CARRY a patient safely through an operation with a minimum discomfort, with perfect healing of the wound, and with ultimate recovery is the hope of every surgeon. To reduce the inescapable risks to a farther and farther receding minimum should be his constant endeavor.

Nutritional experiments have long since revealed the remarkable lowering of resistance to infection and to respiratory disease following vitamin deficiencies. To operate upon patients from the "submerged half" of the population whose long-established diet has been overcooked stews, doughnuts, and coffee undoubtedly increases the risk of distressing and occasionally disastrous complications. Ideally, every patient should be hospitalized one or two weeks before operation with the avowed intention of improving general nutrition and of restoring the depleted store of vitamins. Practically, this is not usually possible. Nevertheless, in our clinic as well as on private services, the preoperative preparation invariably includes a few days of high-vitamin diet, rich in uncooked foods and citrous fruit juices. The importance of the adrenal body in combating infection seems established. Moreover, the adrenal body is richer in vitamin C than any other known substance. One may infer that proper function of the adrenal is dependent upon an adequate, if not generous, intake of vitamin C. Hence citrous fruits are stressed not only in the care of infection but also in its prophylaxis. Whenever possible the high-vitamin diet is amplified by the daily administration of haliver oil capsules and vitamin B tablets. In operations of election, the patient is advised to include these items in his diet for days and if possible for weeks before entering the hospital. All patients being prepared for thoracoplasty are placed upon such a regimen during the preoperative period of observation, study, or sanatorium care.

In any abdominal operation likely to produce stagnation in an atonic bowel, a comparatively empty intestinal tract is less likely to produce postoperative distention from fermentation and the resulting "gas" pains. Accordingly, a nonresidual diet is prescribed for such patients both before and after entering the hospital, preferably for a preoperative period of four to five days. Discomfort due to distention following operations within the abdomen, particularly upon the gallbladder, has been greatly decreased by this precaution.

Operations in the morning are necessarily performed after twelve to eighteen hours of fasting. A stuffed liver is notoriously better fortified to meet the unusual exigencies of anesthesia or the hepatic disturbances incident to cholecystitis and cholelithiasis. By inference, other opera-

tions are similarly benefited. Accordingly, a high caloric eggnog, or a large drink of high caloric fruit juice if the patient is on a nonresidual diet, is served at nine o'clock on the evening preceding the next morning's operation. During the period of iodine preparation of hyperthyroid patients, a diet rich in carbohydrates and vitamins is prescribed, stressing as much candy as the patient can ingest comfortably. Large quantities of fruit juices and water are also administered. The high caloric eggnog on the evening preceding thyroidectomy is considered particularly desirable.

Preceding a serious operation of any nature, such as gastric resection, cholecystectomy, resection of colon, splenectomy, or amputations, the immediate preoperative period of fasting and of water deprivation by mouth is rectified by an intravenous infusion of 1,000 c.c. of 10 per cent glucose solution in normal saline. This is given in the two hours immediately *preceding* the operation. The hyperthyroid patient is never operated upon without this replenishment of liver glycogen *before* the operation, as well as after the operation when indicated. The tuberculous patient is similarly nourished before a thoracoplasty.

The preoperative preparation also includes an enema on the day preceding the operation—not the morning of operation—and an effective sedative in the evening preceding the operation. Preference is given to barbital, 10 grains, plus sodium bromide, 30 grains; or nembutal, 3 grains; or sodium amytal or sodium luminal, 3 grains. This may be repeated the next morning two hours preceding the operation.

In the period immediately following an abdominal operation, care is taken to avoid the ingestion of any food capable of fermentation in the atonic, inactive intestinal loops. Only water is given in the first twenty-four to forty-eight hours, followed by warm tea or hot broth in the next twenty-four hours. Discomfort from gas is a rarity following appendectomy or cholecystectomy, if fermentable substances such as sugars, fruit juices, or milk are prohibited during the period of intestinal atony. If the operation is upon the intestinal canal itself, a Levine nasal tube is introduced into the stomach to avoid gastric distention. Water is permitted freely in the presence of such a tube, as it relieves the discomfort of oral dryness and is harmlessly recovered through the tube in the presence of pyloric spasm or temporary intestinal paresis.

Abdominal distention, as well as pulmonary complications, following operation, is further avoided by insisting on a radical change of position every two hours. A slight shift in position is quite ineffective. A complete 90 degree turn from back to side, and side to back is insisted upon. Occasionally a complete 180 degree turn from back to abdomen is effective in combating and preventing distention. The formerly dreaded gastric dilatation, with "coffee ground" vomitus, is no longer seen or feared following such frequent changes of position. It is only the inert, permanently supine patient in whom this complication occurs.

Large doses of morphia or pantopon are avoided so as not to abolish the cough reflex so necessary in preventing the accumulation of mucus or mucopus in the trachea. To replace the large doses of morphia at infrequent intervals, smaller doses of one-sixth grain of morphia or pantopon are given regularly at three-hour intervals when indicated to control pain, supplemented by sodium bromide or chloral hydrate by rectum, or sodium luminal or amytal hypodermically to promote rest. The control or lessening of pain permits insistence upon coughing and change of position. The patient with a slight throat rattle is encouraged without let-up until the offending pus or mucus is expectorated. In the presence of an abdominal incision, such productive coughing is aided by the firm application of a many-tailed scultetus binder. If large quantities of sputum are being raised, the foot of the bed is well elevated to assist bronchial drainage by gravity. Operations about or in the mouth, such as resection of the jaw or tongue, are performed in the exaggerated Trendelenburg position, and this position is scrupulously maintained for three to four days following operation to avoid the aspiration of infected oral secretions or blood. Even with the patient so placed, change of position from side to side is insisted upon. Voluntary deep breathing at half-hour intervals is likewise insisted upon and has largely replaced CO_2 inhalations.

Beginning with the third or fourth postoperative day, the patient is encouraged to flex and extend the lower legs forcibly against a pillow or bolster at the end of the bed (Cullen). This encourages circulation and prevents venous stagnation in the extremities, in addition to keeping the muscles fit. Without such exercise in bed, the first effort to walk after two weeks' recumbency is attended by unbelievable weakness and often temporarily disabling paresthesias.

Citrous fruit juices and a high vitamin intake are again stressed after the first three postoperative days during the full healing period.

One may safely predict that greater comfort, better healing, and more dependable, uncomplicated recovery will follow adequate nutritional preparation of surgical patients. For such nutritional preparation, one should insist whenever possible upon a much longer preoperative period in the hospital than the conventional overnight stay.

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Recent Advances in Surgery

CONDUCTED BY ALFRED BLALOCK, M.D.

ADVANCES IN ROENTGEN DIAGNOSIS

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Part I

PROGRESS in roentgen diagnosis during the past five years has been extensive and in some respects important. Obviously only those changes of general interest to surgeons and of considerable significance can be considered within the scope of this article.

For purposes of clarity advances must be considered under a variety of headings; none of these are truly independent or singular as they are closely related, but convenience permits a reasonably sharp separation.

ADVANCES IN APPARATUS AND TECHNIC

The ability to do good technical work, to produce roentgenograms which are amenable to accurate interpretation, depends in large measure upon the quality and character of the x-ray equipment. The most striking change in this regard has been in the manufacture of transformers. During this period, the American producers of roentgen apparatus have changed from the mechanically rectified type of transformer to kenetron rectified machines. While this has increased, to some extent, the cost of equipment and has added additional hot cathode tubes requiring replacement, nevertheless, it represents a distinct step forward. The advantages of current rectification by means of valve tubes are much more apparent in roentgen therapy than in diagnosis; even in the latter, however, this type of current is far superior. If four valve tubes are used a fully rectified, steady, readily controllable current is produced. It is easily possible to attain as high as 1,000 ma. of current at diagnostic voltages; the output of the x-ray tube is much more steady; the type of radiation curve is far superior for use with the Bucky diaphragm.

The second important development concerns itself with shockproof installations. Despite the fact that there have been relatively few serious accidents resulting from contact with the high tension side of the x-ray apparatus, these few have been so unnecessary that the de-

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velopment of reasonably priced equipment entirely free from this danger has been wholly welcome. Furthermore, shockproof units have permitted the establishment of new technical procedures such as lateral views of the hip joint and proximal end of the femur, lateral and oblique views of the shoulder, angulation views of the head, greater facility in bedside roentgenography and fluoroscopy.

A remarkable improvement in the quality and durability of the roentgen tube has taken place these past few years. The adoption of the line type of focus permits us to utilize a much smaller effective focal spot with greater loads. This, naturally, results in a great improvement of detail and diminution of distortion. While these improvements have not been startling, the development of a practicable rotating anode tube promises much more. Within the past few years such an equipment has become available making it possible to make roentgenograms with a tube of exceedingly fine focal spot (less than 1 mm. effective) without prolonging the time of exposure or unduly reducing the peak voltage. Such x-ray tubes may well change our concepts about roentgenology of the spine, gallbladder, urinary tract, and other heavy parts. In the spine of heavy individuals, for example, distortion has been tremendous under present conditions. The relatively short tube-film distance, the relatively long object-film distance, together with a fairly large sized focal spot has produced vertebral bodies which in the roentgenogram appeared to be almost double their actual size. With the increase in size there is almost a corresponding decrease in detail and definition. The use of this new type tube arouses hopes for greatly improved technic in the diagnosis of pulmonary diseases as well.

Changes in the construction of the Potter-Bucky diaphragm now permit a marked increase in speed of exposure. Whereas previously it was difficult to avoid grid lines on a film even at a half-second, with a special type of grid exposures as rapid as one-fifth or possibly one-tenth of a second can be made with a fair degree of freedom from markings. This makes it possible to make roentgenograms of the chest with the diaphragm without sacrificing the speed which is so essential in dealing with the lungs. The diaphragm technic is particularly of value in dealing with surgical conditions of the thorax; the results of roentgenography in thoracoplasty cases and in lungs which are heavily infiltrated from bronchiectasis, tumor, or empyema are greatly improved by this means. The invention of a stationary filtering diaphragm (the Lysholm grid) has also made it possible to improve bedside roentgenography of heavy parts such as the hip or spine; it is easily portable and eliminates a fairly large share of the scattered radiation.

It should also be noted that wheel stretchers are now available which are radiotransparent and fit closely over a Potter-Bucky dia-

phragm. In dealing with seriously ill patients, these afford a means of making roentgenograms with the grid without removing the patient from the litter upon which he was transported to the x-ray department.

Fluoroscopic units have been greatly improved, first, by making them shockproof, second, by increasing the illumination produced on the fluoroscopic screen, and last, by the production of a practical device for "spot-film" work. By the latter means, roentgenograms can be quickly made during the course of fluoroscopy in order to record findings fleetingly or imperfectly observed under the screen. This is of substantial value in the diagnosis of diseases of the gastrointestinal tract, in bronchography and in myelography.

Kymographic apparatus has just been made generally available in this country. While the practical value of this equipment may still be debated, it no doubt adds something to the armamentarium of the roentgen diagnostician. By means of this type of moving grid, a roentgenographic picture of the motion of various organs can be obtained. Perhaps it is an oversimplification to state that this equipment facilitates the permanent recording of the motion which can be so readily seen by fluoroscopy. As such it is particularly applicable to the study of the heart, the ribs, diaphragms, lungs, esophagus, gastrointestinal tract, and kidney pelvis. The advantages of this apparatus in diagnosis of the surgical diseases of the thorax have already been well established. The general aspects of this type of roentgenographic technic have been thoroughly described by Stumpf.[1]

An extremely complicated piece of machinery is being used abroad for planigraphy or tomography.[2-5] By means of this apparatus it is possible to make roentgenograms of organs in any plane, the selected plane appearing reasonably sharp and distinct, while all the structures anterior and posterior to it appear to be out of focus. The localization and demonstration of deep-seated cavities in the lung, for example, can thus be accomplished. It is too early to state positively, however, whether this equipment will be of lasting value.

From the standpoint of technic, there have been few radical changes. Outstanding among them, from the point of view of the surgeon, are the procedures for making lateral views of the hip. Several methods have been described. George and Leonard[6] advocate the use of a curved cassette placed within the crotch of the patient while the tube is directed from a point above and lateral to the greater trochanter. Wittek-Salzburg[7] and Johnson[8] use the ordinary cassette, and with a shockproof unit, the tube is placed between the thighs, the cassette on the outer surface of the hip. Particularly in cases of intracapsular fracture, the lateral (often called vertical) projection permits greatly improved diagnosis as to the position of the fragments of the femoral neck.

Likewise lateral views of the shoulder can be obtained by the technic of Jordan-Narath[9, 10] so that the position of fractures of the upper humerus, calcifications of the supraspinatus and other tendons can be much more readily determined. Philips[11] has described a lateral position for the clavicle which is useful in determining more exactly the position of displaced fragments.

While much has been written on roentgen pelvimetry, the simplest method of recent years is that described by Ball and Marchbanks[12] utilizing a device for the mathematical correction of the errors present in the usual roentgenogram. Stereoroentgenography, as described by Hodges and Ledoux,[13] is more complex but is also of considerable value. Moloy[14] using stereoscopy also advances a simpler procedure.

Numerous studies of the technic of exposure in postoperative chest conditions have been made. The problem of obtaining readable films of the normal lung while penetrating sufficiently the surgically collapsed or heavily infiltrated abnormal lung has been solved in a number of ways. Obviously the simplest procedure is to make two roentgenograms, one with the usual chest technic, the other with much greater than normal exposure, with or without the use of a Bucky diaphragm. Determan[15] advocates the use of a filter blocking out part of the radiation on the side of the normal lung. Sampson[16] uses a lead protector, exposing half the film only for the normal side; this is followed by a Bucky diaphragm exposure of the abnormal side on the unexposed half of the film. An opaque plastic covering the normal side of the chest is suggested by Gershon-Cohen;[17] by this means, radiation through the normal lung is reduced.

Soft tissue radiography for the demonstration of soft tissue tumors, inflammatory changes, vascular abnormalities has been developed particularly by Carty.[18] Further studies of technic in radiography of the breast have been made by Lockwood[19] and Fray and Warren.[20] The latter emphasize the value of stereoscopic films.

Changes in the methods of gastrointestinal examination have been characterized by the increased use of the so-called mucosal technic. In this is embodied the use of small amounts of barium mixture, the application of pressure to the area of involvement, and the making of roentgenograms under fluoroscopic guidance. The utilization of various types of barium meals and their effects is well brought out by the studies of Ravdin and others.[21] In general a barium water mixture is being adopted. This is, no doubt, the most effective meal for examination of the small intestine, to which attention has been recently directed. In the examination of the colon, the double contrast enema[22] and the use of colloidal substances for demonstration of the mucosa[23] are not new but have been more widely adopted.

The technic of cholecystography has been modified largely by the introduction of the divided dose method of administering the dye[24]

together with the addition of a carbohydrate meal or intravenous glucose (Antonucci, Sandstrom,[25] Stewart and Illick[26]). This produces much more intense shadows when the oral method is used, while greatly hastening the appearance of the shadow when the dye is given intravenously.

Pirie[27] advocates a new method for the localization of foreign bodies in the eye. This depends upon the fact that x-rays afford a direct stimulation to the retina. A metallic foreign body will produce a density in the circle of illumination seen by the patient when his eye is exposed to an x-ray beam. Aid in the removal of metallic foreign bodies from the eye can be obtained by the use of the biplane fluoroscope.[28]

Ghormley and Kirklin[29] have called attention to the importance of oblique views of the spine to demonstrate the articular processes and their joints. Intrarectal radiography for improved roentgenograms of the coccyx is described by Sabat.[30]

Fluoroscopy at the bedside can be readily accomplished if the apparatus devised by Sgalitzer[31] is constructed. Ledoux-Lebard and Saget[32] believe it is feasible to do fluoroscopy in illuminated rooms by means of a monochromatic light for general illumination and a colored filter in the glass over the fluorescent screen. The possibility of doing fluoroscopy in the operating room is thus greatly enhanced.

The development of methods for making indirect motion pictures, i.e., reproductions of the images on a fluorescent screen, has now proceeded to the point of practicality. For the time being this is largely of importance for teaching purposes, but the potentialities for improved diagnosis cannot be overlooked.[33-35]

(Part II will appear in the next issue of SURGERY.)

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Review of Recent Meetings

REVIEW OF THE FIFTH ANNUAL MEETING OF THE AMERICAN ACADEMY OF ORTHOPAEDIC SURGEONS

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THE Fifth Annual Meeting of the American Academy of Orthopaedic Surgeons was held in Cleveland on January 10 to 14, 1937, with a registration of 681 surgeons marking this as the largest and most successful session. The examination sponsored by the American Board of Orthopaedic Surgery preceded the general program.

Monday, January 11, 1937, was a clinical day presented by the local men. Among the cases shown were some of congenital scoliosis in older female children accompanied by the development of complete paraplegia. Laminectomy in the affected area cleared up the compression on the cord and complete restoration of function occurred. Several cases of sciatic pain and backache due to enlargement of the transverse process of the fifth lumbar vertebra were shown. They presented atrophy of the leg, pain and limp on the affected side; all received complete relief from symptoms following removal of the enlarged process. A large giant-celled tumor of the lower third of the radius had been resected and the defect in the shaft of the bone made up for by a massive graft into the carpus. There being no recurrence of the tumor a year later, resection of a segment from the lower end of the ulna gave a very excellent range of supination and pronation of the forearm. A knee joint arthroplasty, repair of cruciate ligaments, and repair of lateral ligaments of the knee joint were shown with excellent stability and painless motion.

Music in the bones was the theme of one presentation in which the transmission of vibrations of a tuning fork or electric oscillator through osseous tissue and across joints gave information as to the state of continuity in the bone, the accuracy of reduction of a fracture, or the degree to which healing had advanced.

Tuesday, January 12, 1937: **Dr. Merrill Mensor**, of San Francisco, gave a paper on injuries of the accessory processes of the vertebrae and showed some excellent x-ray studies of fractures through these parts of the spine. It is difficult to differentiate congenital anomalies from fractures in the absence of a history of trauma except by repeated roentgenograms which would probably show progression toward healing in the case of fractures and no change in the case of congenital lesions. The necessity for roentgenologic studies from various angles and their accurate interpretation is of great importance in making a diagnosis. The lesion should be suspected if severe backache follows a marked torsion strain with or without flexion or extension. Failure to recognize the condition frequently leads to nonunion and persistent backache which may require surgical interference for its correction. The possibility of facet fractures accompanying any crushing injury of the vertebral body must be kept in mind and care should be taken to have a traction element acting when reduction of the spine fracture is undertaken.

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Dr. Henry Kessler, of Newark, N. J., presented three men who had upper extremity amputations of the cineplastic type which made it possible for them to return to occupations requiring the active use of both arms. The remaining muscles in the arm or forearm stumps were used to make motor loops activating levers in the artificial member opening and closing the hand. In some, it was possible to obtain pronation and supination in the forearm by straps operated from the opposite shoulder. The artificial member can be used so satisfactorily that the patient willingly wears it with pride in achieving difficult manipulations such as writing, handling papers, cards, violin bow, tying neckties, etc.

Dr. C. Leslie Mitchell, of Detroit, reviewed the subject of the clinical significance of the serum phosphatase, stating that the studies are of definite value in Paget's disease, osteitis fibrosa cystica, and osteogenic tumors but of no value in other conditions. It is interesting to note the drop in the serum phosphatase as a result of removal of the primary tumor mass, only to see it rise again with the development of metastases. Discrepancies in the phosphatase determinations and its physiologic action in various diseases were pointed out. The level of phosphatase in the blood may not necessarily be an accurate index of the amount of new bone formation or the attempt of the body to form bone, and cellular activity in the bone concomitant with the healing of fractures is not reflected in any well-defined elevation of serum phosphatase.

Dr. S. Kleinberg, of New York City, presented cases of femoral neck fractures which were treated successfully by conservative means with the added factor of early weight-bearing in plaster. After manipulation of the fracture by the Leadbetter modification of the Whitman technic, the reduction was checked by "heel-palm test," measurements of the length of limbs to demonstrate equality, and x-ray studies. A closely fitted plaster of Paris spica practically unpadded and accurately moulded over the great trochanter and iliac crest was applied from the toes of the affected side to the axillae. In from three to seven days after the fracture, the patient was placed upright on her feet for a few minutes several times a day. In ten to fourteen days, she walked in her room with abundant assistance; and from then on, the amount of activity allowed seemed to depend largely upon the physical ability of the patient. "Blow-bottles" were used to encourage hyperventilation. The plaster of Paris spica was removed at the end of two months for x-ray and then replaced by a short spica for a further four to six weeks, then a corset for one month. The statement was made that bony union was demonstrated in the x-ray taken two months after the fracture. There was more general disagreement on this point than on any other in the presentation. In the analysis of cases, the average age was sixty-four years. Bony union was obtained in twenty-two of the twenty-four cases, and the patients were walking with a cane by the end of three months.

A discussion of the intrinsic, traumatic, and extrinsic theories of the causation of torticollis was given by **Dr. F. Kidner**, of Detroit, which was based on an analysis of seventy-four cases under his personal supervision. Microscopic examinations were made in operative cases showing the condition to be largely local hyalinization and destruction of the striated muscle with scar tissue replacement. Hematoidin crystals also pointed to a hematoma as the causative factor. If the muscle rupture and hemorrhage involved a segment of the muscle through part of its circumference only, the torticollis deformity did not develop; but if an entire segment was involved, deformity was inevitable. If the sheath of the sternomastoid muscle is divided and closed with a deep suture after resecting a portion of the lower end of the muscle as recommended by the author, there is

no need for any postoperative fixation. Kidner has had only one recurrence in nineteen years and that was in a patient who did not remain under treatment following operation.

Great interest was shown in the shoulder seminar conducted by **Dr. E. A. Codman**, of Boston. Men who have done outstanding work in the study and treatment of shoulder joint lesions had been invited by the chairman to present various phases of the question. Muscle transplantation for circumflex nerve paralysis was discussed by **Dr. Frank Ober**, of Boston. Forty-one cases upon whom fifty-four operations had been done were used for this analysis. The operation consists essentially in the transplantation of the long head of the triceps and short head of the biceps to the acromion of the scapula with the shoulder held in abduction. The best results were obtained in those children whose muscles were normal except for the loss of the deltoid power. Definite improvement in stability and function was obtained in most cases. In eighteen of the children, normal stability was obtained.

Dr. R. Patterson, of New York City, told how salt solution injection in painful shoulders has brought dramatic relief in acute painful lesions. A detailed description of the technic used in lavage of the subacromial bursa with salt solution was given. Material obtained was thick and creamy like "tooth paste." In most cases, pain was gone after the first syringe full of saline solution. Total quantity used was about two ounces. Temporary use of a sling for partial support with complete function in the arm after four to six days was the usual history. This technic promises to cut down the prolonged painful disability in acute subacromial bursitis.

Whether the rupture of the long head of the biceps brachii is due to trauma, wear and tear, or atrition of old age was discussed by **Dr. E. Gilcreest**, of San Francisco; and in spite of many excellent slides showing the pathologic condition at operation, methods of repair and restoration of function, it is quite apparent that there is not as yet any general agreement on the etiologic factors responsible for the condition.

Four recent acute cases of rupture of the supraspinatus tendon were presented by **Dr. Leo Mayer**, of New York City. All had been treated by operation at which the pathology was easily demonstrated. Some difficulty is encountered in exposing the retracted proximal end of the tendon and in fastening it securely to its anatomic insertion. Motion in the shoulder should not be started in less than four weeks and one should not expect to get full return of power in the muscle, although there need not be any functional loss in the shoulder. Excellent colored moving pictures of the lesion and operation for its repair were shown by **Dr. D. M. Bosworth**, also of New York City.

Wednesday, January 13, began with a paper on the Schanz osteotomy for femoral neck fractures by **Dr. Herman Schumm**, of Milwaukee. The indications for this procedure in the hands of the author were definite nonunion or fibrous union with coxa vara. The difference between high Schanz and low Schanz osteotomies and the Riedel modification of the technic were mentioned and the author's preference for the latter stated. Greater stability and improved efficiency of the gluteal muscles is obtained as a result of improving the lever action of the upper end of the femur. If there is a genu valgum present prior to operation, this is likely to increase and become a factor in the production of pain later on.

Advantages: Stability, relief of pain and fatigue, and in some cases union of the fracture of the femoral neck takes place. Complications: Delayed union in four of the twenty-eight cases reported; increase in genu valgum; loss of angle at the site of osteotomy. The use of this procedure in osteoarthritis was also mentioned, the arthritic head being removed and then an osteotomy done to relieve pain and produce stability.

Dr. E. Wolcott, of Des Moines, Ia., reported again on his work on circulation and nutrition of the head of the femur and showed radiographs of specimens injected with metallic mercury. He has traced a branch from the medial circumflex branch of the profunda femoris artery through the cotyloid notch to join with the artery of the ligamentum teres to supply blood to the epiphyseal portion of the head of the femur. The feeling was expressed that although these studies reveal that 20 to 25 per cent of femoral heads receive no blood supply through this ligament which may be a factor in the failure of fractures of the femoral neck to unite, there are undoubtedly other factors which must always be kept in mind such as important shearing stresses at the site of fracture and interposition of soft parts in fracture line. It is probable that shearing stress is the most important element to be considered.

The Colonna operation for ununited fractures of femoral neck in which there has been complete absorption of the neck was again reported by the author. He has had fifteen cases in whom he has been able to restore stability, preserve motion, relieve pain, and reduce the amount of existing shortening. This method must not be used if there is any neck left or any bony spicules on the medial side of the shaft at the base of the neck. Motion pictures were shown of the patients walking, climbing steps, abducting the thighs, etc.; and the degree of motion and stability obtained was obviously very satisfactory.

A paper was given by **Dr. William Cubbins,** of Chicago, on the "nailing" of fractures of the neck of the femur. He has advocated the Callahan technic using a trough or V-shaped nail inserted through an anterolateral incision through which the capsule of the hip joint can be opened for inspection of the fracture site. Motion pictures visualized the technic used.

Dr. C. B. Higgins, Milton, Mass., presented his interesting work on the effect of temperature changes on the distribution of red and yellow bone marrow in the skeleton and mentioned the reticulocytes in the red marrow as perhaps having something to do with the plan of distribution of secondary malignant deposits in the bone.

A symposium on fractures of the ankle was presented by **Dr. Sumner Roberts,** of Boston; **Dr. Robert Schrock,** of Omaha; **Dr. William Darrach,** of New York City; and **Dr. J. S. Speed,** of Memphis, Tenn. The etiology and classification, the treatment of severe fractures, operative methods in treatment of severe fractures and the treatment of malunited and disabling ankle joint fractures were taken up. There was no especially new information brought out except that in the treatment of severe comminuted ankle joint fractures involving more than one-third of the tibial joint surface and in the bad T- and Y-fractures, it was recommended that an ankle joint fusion be performed. There was definite dissension on this point as being a little too radical. Prolonged fixation after early accurate reduction seemed safer and productive of good results in the hands of a number; whereas, others recommended fusion if there was any question of painful function being the end-result.

Thursday, January 14, 1937: **Anthroplasty of the Hip Joint. End-Result Study of Seventy-Nine Unselected Cases by Dr. Hulford Hullock,** New York City, was first presented.

This was a study of seventy-nine cases treated in one hospital by various surgeons and various technics from 1919 to 1934. The etiologic factors responsible for the ankylosis requiring arthroplasty included osteoarthritis, septic arthritis, coxa vara, slipped femoral epiphysis, etc. The results were very poor as mobility was unaffected or lowered in 71 per cent of the cases. Most cases had painful hips after operation although stability was good. Since 1934, technical improvements have increased the so-called good results although pronounced pain and limp often persist after operation.

Dr. B. Moore, of Chicago, presented a paper on **Effect of the Periosteum on the Position of Fracture Fragments,** in which he showed that the periosteum has a definite mechanic effect in assisting or impeding the reduction and retention of the fragments of a fracture. He made a plea for gentler manipulations of fractures and an understanding of what the torn or stripped periosteum may be expected to do in helping or hindering the reduction.

Three papers on tuberculosis of bones and joints were read. The first by **Dr. A. B. Ferguson,** of New York City, dealt with the soft tissue shadows of the joints and the information one can obtain regarding effusion, atrophy, infiltration, chronicity of the lesion, and so on. Aided by the clinical history, it is possible to make a diagnosis of tuberculosis of a joint even before osseous changes are apparent. **Primary and Secondary Osseous Lesions in Tuberculous Arthritis** was presented by **Dr. C. H. Hatcher,** Chicago. He stated that tuberculous involvement of the joints is usually another manifestation of a primary lesion elsewhere in the body. The location of the lesion may be in the bone or synovia. The lesions in children are rarely found in the epiphysis; whereas, they are more usual in the epiphysis in adults. Some excellent colored photomicrographs added much to the value of the paper. The case for **Tuberculosis of the Spine in Children** was again stated by **Dr. E. F. Cave,** of Boston. One hundred twenty-two cases have been treated in the past seventeen years. Diagnosis was made on history, clinical, x-ray, serologic, and laboratory findings. Sixty per cent of cases showed positive pulmonary changes and 75 per cent of cases develop tuberculous abscesses. Mortality of 17 per cent was reported, most of which was due to development of amyloidosis. Fusion in twenty-two cases was done after the disease was quiescent as a means of preventing deformity and recurrence.

A symposium on **Low Back Lesions** with **Dr. Joel E. Goldthwait,** Boston, as chairman occupied the entire afternoon of the last day of the meeting. **Dr. Theodore H. Willis,** of Cleveland, spoke on the **Anatomical Structure of the Lumbar Region Including Variations.** Many of the common variations found in 27 per cent of cases were mentioned. Backache due to enlarged transverse processes was frequently relieved by postural treatment which was designed to correct mechanical strains placed on the anomalies at the lumbosacral junction. **Dr. E. L. Compere,** of Chicago, followed with the **Operative Treatment,** presenting tables showing indications for various forms of surgical procedures and the results obtained.

Sacrococcygeal Lesions were discussed by **Dr. J. Albert Key,** of St. Louis, with special mention of the chronic type of coccygodynia. Operative removal of the coccyx is definitely indicated if chronic disability is produced. A carefully per-

formed operation, removal of the entire coccyx by sharp dissection, beveling the lower end of the sacrum, and closure of the deep pelvic floor should give satisfactory result with complete relief of pain.

The Mechanics of the Lumbosacral and Sacroiliac Joints were discussed by **Dr. L. T. Brown**, of Boston.

Nerve Root Pain Due to Intraspinal Protrusion of the Intervertebral Disk was presented by **Dr. J. G. Love**, of Rochester, Minn. Diagnosis of the lesion is made in cases of intractable back pain, which do not yield to the customary measures, by lumbar puncture to determine total protein content of the spinal fluid. If this is elevated, lipiodol injection reveals a filling defect at the site of the lesion. Reverse Queckenstedt test shows marked increase in the pain referred on the affected side. Laminectomy with removal of the protruded disk has led to relief.

The final paper concerned with **The Compensation Aspects of Low Back Conditions** was presented by **Dr. H. L. Prince**, of Rochester, N. Y. A plea was made not to frighten the patient into believing that his condition was a very serious one. Acute back sprains should be treated with adhesive plaster, a few days' complete rest, and relaxation in bed using narcotics if necessary, followed by early active exercises and return to work. The common use of plaster of Paris and mechanical brace support can be quite dangerous to the mental attitude of the individual as well as prolong the period of disability.

Book Reviews

Williams' Obstetrics: A Textbook For the Use of Students and Practitioners. Edited by Henricus J. Stander, Cloth Pp. 1269, with 729 illustrations. New York, 1936, D. Appleton-Century Company, Inc.

When the author of this revision states in his preface, "an attempt has been made to retain as much of Dr. Williams' last revision as is consistent with the new developments in obstetrics," the reader is prepared for a continuation of the conservative dignity of the previous Williams' revisions. In the rewritten chapters, little can be found that departs from the high standard of obstetric literature set by the late Dr. Williams.

Three new chapters are found in the book. The first of importance from the standpoint of the practitioner is the chapter dealing with the hormones as related to menstruation, pregnancy, parturition, and lactation. Here is a precise, understandable summation of a subject around which a voluminous incomprehensible literature has accumulated. To the practitioner interested in undertaking endocrine therapy, this addition should be of value in serving as a base from which excursions may be made into more complex reading. Another new chapter, second in interest if not in importance, is the chapter dealing with obstetric anesthesia and analgesia. All of the common, newer methods are detailed. Here again, a sizable literature, which while not as incomprehensible as in the case of the hormones, but yet somewhat confused by personal enthusiasms is epitomized into a workable understanding. The free use of morphine described in the routine analgesia of the New York Lying-In Hospital is a surprise, in view of the general exclusion of this drug during labor in most places. The third new chapter and the one which probably will be read the least, because of the lack of exploitation of the subject, is the one dealing with diseases of the kidneys and urinary tract. Here is found a concise description of the physiology of the urinary tract during pregnancy, an understanding of which is fundamental to clinical obstetrics, and which, while an old subject, has had a recent revival of interest among urologists.

In the section of the book dealing with the physiology of pregnancy, the chapters concerned with the "changes in the maternal organism resulting from pregnancy" and the "management of normal pregnancy," could be more effective if combined or placed adjacently. For what is the management of normal pregnancy if it is not the close observation and attempted regulation of the maternal physiologic changes resulting from pregnancy? Obstetric consultation practice reveals that lack of even reasonable antepartum care is one of the faults in American obstetrics today. Certain formal "prenatal" examinations and recommendations are made, but many times without intelligent interpretation of the results. Consequently, any emphasis of the antepartum phase of the subject of obstetrics would seem desirable.

Pelvimetry is described in the section of the book dealing with the pathology of labor in the chapter concerned with contracted pelvis. This placing of the subject causes some loss of accentuation on the use of pelvimetry as a routine procedure. Pelvimetry as a function has reached new proportions with the development of radiographic technics and could properly be accorded the dignity of a chapter, which, with the inclusion of some simple pelvic classification such

as described by Burgess, would give a foundation to the student and practitioner in studying the excellent chapters dealing with the bony pelvic abnormalities.

Unquestionably, the book remains substantial among obstetric texts and should be accorded a prominent place in the library of the practitioner and student.

Medical Morals and Manners. By H. A. Royster. Cloth. Price $2.50. Pp. 333. Chapel Hill, N. C., 1937, The University of North Carolina Press.

The American student of medicine of our day has become familiar with the charm of philosophic medical essays in monographic form largely through the delightful *Aequinimitas* of the late William Osler and the equally refreshing *Consecratio Medici* of Harvey Cushing. A fairly large number of monographs of this type have come from the pens of distinguished English and American men of medicine and surgery. In a manner, such essays may be said to be in part autobiographical in character, for they reveal the interests and outlook of the author in many reflective moods.

Such, too, is the subject matter of this text in which a well-known American surgeon discourses upon a variety of topics. There are in all thirty-one essays, listed under five headings. The majority of the papers are addresses which have been delivered before medical audiences; some are semipopular in nature. This collection of philosophic essays interestingly written by a thoughtful surgical idealist, given to meanderings into nonmedical literature and possessed of a well-developed historical sense, should find favor with students of surgery.

Lectures on Embolism and Other Surgical Subjects. By Gunnar Nyström. Cloth. Price $3. Pp. 213, with 66 illustrations. Baltimore, 1936, Waverly Press, Inc.

This small volume of five chapters relates to lectures given by the author as Abraham Flexner Lecturer at Vanderbilt University. A note on the Abraham Flexner Lectureship by Chancellor James H. Kirkland and a foreword by Barney Brooks introduce the monograph to American readers. The name of Gunnar Nyström, professor of surgery at the University of Uppsala, Sweden, has become well known to American surgeons in the last decade through his surgical successes with pulmonary embolectomy. The problem of pulmonary embolism and embolism of the arteries of the extremities and their surgical treatment are well discussed. Equally interesting to American surgeons is the informative chapter on the treatment of fractures of the anatomic neck of the femur. Smith-Peterson's method of dealing with these fractures together with Sven Johansson's modification which are widely practiced in Sweden are well illustrated and described. The remaining two chapters deal with the problem of appendicitis in Sweden and the cytology of joint exudates. The author inclines to the belief that all instances of acute appendicitis, no matter what the extent of the disease, should be treated surgically —a thesis which is rapidly losing ground in the United States.

This volume can be enthusiastically recommended to all practitioners of medicine who have an interest in the subject matter.

The Law of Drugs and Druggists. By William R. Arthur. Cloth. Pp. 487. St. Paul, 1936, West Publishing Company. $3.

The author, who for several years has been giving the short course on drug law to the senior classes in the School of Pharmacy at the University of Colorado, carries on the work in this volume that was commenced many years ago by Dean Washburn, of the School of Pharmacy, and himself.

This book is ideal for physicians, pharmacists, and nurses who desire to know something of the legal aspects of the medical profession, and for those who wish information concerning the relationship of law in the practice of medicine in so far as the dispensing of drugs is concerned.

Part I covers state and local laws and is of special value to pharmacists. Part II covers the subject of federal statutes and relations. One chapter covers the subject of the Harrison Anti-Narcotic Act. Actual court cases are cited. Many points are made clear for the guidance of the prescribers and dispensers of drugs.

The aim has been to cover in a concise and practical manner the area wherein law and the prescribing and dispensing of drugs overlap. For the benefit of the physician and pharmacist, the legal terminology could have been much reduced and technical terms could have been simplified in an effort toward clarity as well as accuracy.

A doctor once said: "If a man knows what malpractice is, he can almost avoid it. In other words, the more law he knows, the more he can be kept out of court or at least the terrors of it."

This book can be well recommended, especially to the students of pharmacy.